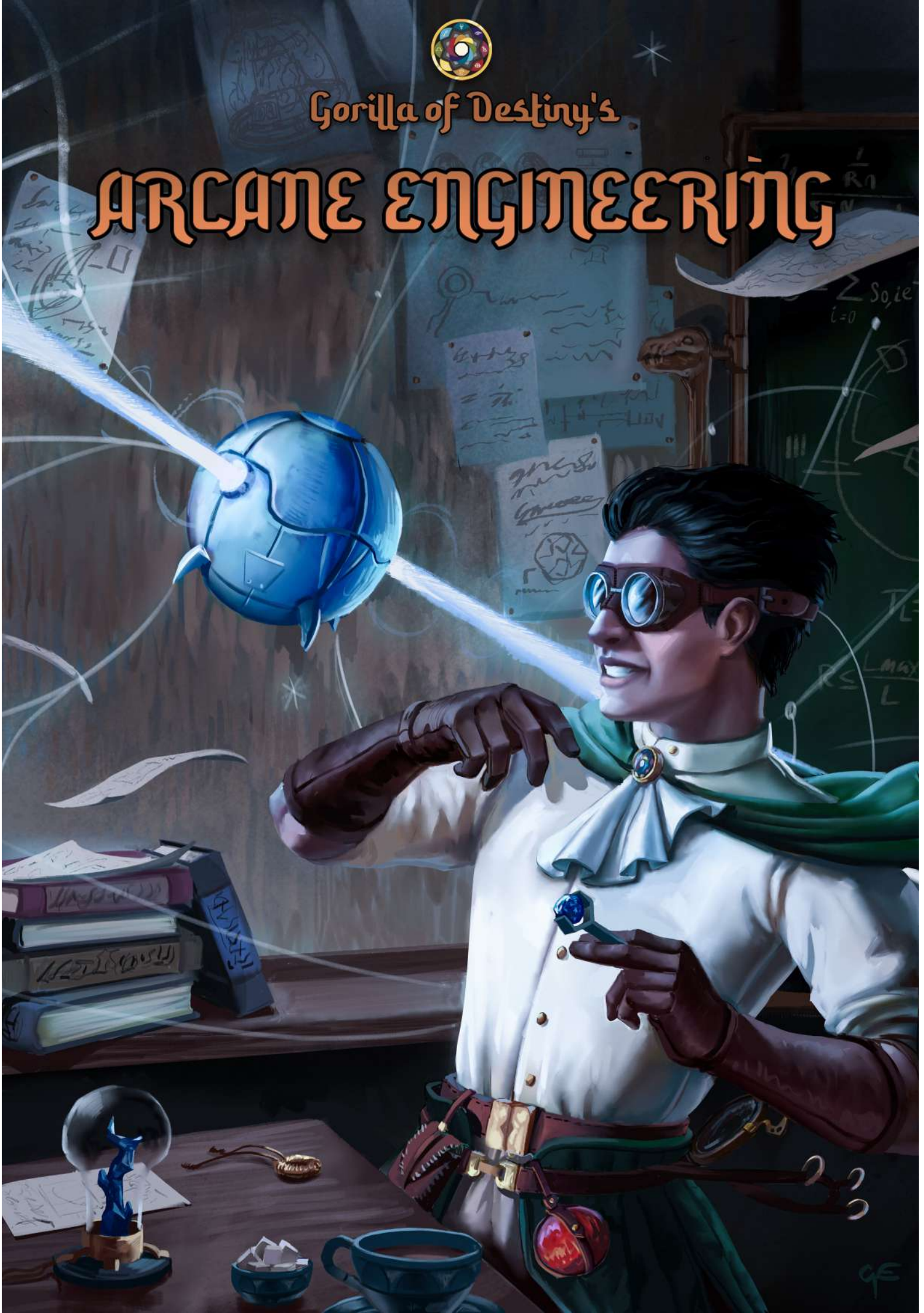
Gorilla of Destiny's
ARCANE ENGINEERING

Arcane Engineering

The Gorilla of Destiny

September 20, 2024

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Chapter 1: Introduction

Some people have the gall to say wizards can't invent things, but with the power of our in-depth analysis and far superior intellect, we are more than capable of making enchanted, autonomous, and arcane systems with nearly twice the organisation and half the lethality of the other schools of engineering. This book is split into 5 chapters. First up is **The Introduction**, which you're already reading, good job. Following that, we have the real meat of the project, **The Theory of Arcane Circuitry**. The Theory will be very technical, and in this chapter we will explore the implications of the theoretical choices made, but for the sake of everyone else at your table, we will then move onto the third chapter: **Rules Implementation**. If you aren't that excited by the maths, this is the chapter for you; it contains all the information you'll need to actually play the class with rules based off of the theory. After this, we have the **Arcane Engineer Subclass**. This is just a simple combination of some of the rules into a subclass for you to use in your own games. Finally, we have **Arcane Engineering Examples**. these are some circuits I've made up that I *think* follow the rules, unless otherwise stated.

This book has become a huge project sort of by accident. I appreciate everyone's patience around its writing, and I hope that it can somehow live up to your expectations. However, like all my work, there are likely a myriad of typos, errors, inconsistencies, contradictions, and mistakes. If you find any, please just let me know (email is best: gorillaofdestinytiktok@gmail.com), and I will attempt to rectify them ASAP.

Finally, I would like to thank George Eracleous for all the wonderful art in this book as well as Stenis for the graphic design of the heraldry, page background, and the circuit diagrams in the Arcane Engineering Examples. And, of course, I would like to thank all of you for your continued support. If you enjoy my work, a rating is much appreciated, but don't feel obligated.

Thank you, The Gorilla of Destiny.

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Chapter 2: Theory

One key thing that I have to emphasise a lot throughout my work is "Magic isn't real." Now, obviously, I'm not talking about the magic of hearing a song from your past you had never forgotten but couldn't remember, the magic of laughing with your friends so hard your head begins to hurt, or even the stage shows involving cards and cups. No, what I mean is that the magic, as described in the rules of 5e, is almost certainly not true. When we play these games, we must accept a certain amount of fantasy and deviation from our otherwise sensible universe. This isn't to the detriment of fantasy. In fact, one of the main appeals is being able to escape from the boring, and often much more complicated, rules of reality and tell stories in strange worlds but with real human truths at their core. When we embark on these "scientific" magic projects, we have to "buy into" this a little bit. We must remove ourselves from reality and instead think of ourselves as scientists in these different and strange worlds, including all their ridiculous rules. We can't fall back on real-world understandings and must instead build our new science on the fantastical evidence presented to us. Most often, that evidence comes in the form of a rule book.

We are forced to import some understanding from our reality, such as the fact that $c^2 = a^2 + b^2$ in the universe's geometry despite the rule book saying that the length of the diagonal on a 5x5ft square is 5ft. If we took that at face value, the geometry of our fantasy world would be so unrecognisable and technically complicated that we would never get anything done and probably leave quite angry. Similarly, if we had to specify that we are moving 7.071...ft every time we moved diagonally, we'd get frustrated with the game. So, we assume these particular rules are just simplifying the reality of our movement for the player's convenience and not as a bold scientific statement that the space-time curvature of the fantasy world is so fundamentally altered that it justifies these distances.

Therefore, we have two kinds of evidence: hard rules that have no real-world allegories (i.e., spell levels, damage, hit points, etc.) and rules of convenience that we can ignore. Why I even mention this is because we are going to be building a system for magic circuitry. Much to my undergraduate self's dismay, circuitry is a real thing. The real-world rules of electromagnetism are *complicated* and not entirely useful to the very discreet world of 5e magic. So, here we are, obviously taking inspiration from the real-world, but most importantly, we want to try and keep faithful to the in-universe evidence and not get distracted trying to make the complicated, nuanced, and fascinating world of real-life circuitry *impede* (get it? if you don't, keep reading, then come back and have a good 5 to 10 minutes of laughing to yourself before leaving a five-star review) our development of arcane circuitry. Similar to our distance calculations, however, much of the theory we develop as a result of the rules we see will be too frustrating to impliment directly and so we will also present a simplified version of the rules for play.

Finally, at the end of this section, I will try and include a short recap of all the different components.

How Spells Move in a Circuit

Real Circuitry Basics

In the earlier stages of whatever physics education you might have had, you may have been told to think of circuits as electrons moving around a circuit, being given a certain amount of energy (called voltage), which they then deposit at the various components (resistors, lamps, etc.). Somehow, these electrons know to spend their energy exactly so that they return to the battery with absolutely none left. This isn't quite right but is useful as a starting example. In reality, currents flow because of a "push", and the voltage describes how strong this push is. The "push" comes from the repelling force like charges (charges with the same sign) give each other (similar to how magnets attract if you have opposite poles but repel if you have the same pole). An electron is moved by some electromotive force (emf), which then causes the next electron to feel a push from their mutual repulsion, which will then repulse the following electron, and so on, and so forth. When we flip a switch off, we break the loop, which means there is nowhere for pushed electrons to go, stopping the circuit. The flow of this electric charge is called the current (analogising very well with a current of water), and different components require more or less energy to be pushed through. This resistance to this flow is called (wait for it) the resistance. Ohm's Law tells us the relationship between these three properties:

$$I = \frac{V}{R} \tag{2.1}$$

where Current I is defined by the voltage V and resistance R. Components with a higher resistance require more "pushing" from the voltage, and that affects the current of the entire circuit. One of the key takeaways from this is that current is the same everywhere in the circuit (provided it doesn't split anywhere, see next section). It is not like a river with some regions of high speed and some of low, but instead, the flow is constant due to the balancing of the emf given by the battery and the resistance of the circuit. In Ohm's law, you can see this quite neatly: if we increase the voltage of our battery, then we get an increasing current; if we

increase the resistance, we will have a decrease in current (and vice versa).

As mentioned earlier, though, the current can be different in different components of the circuit, but in order to understand why, we must look at Kirchhoff's Laws (Next Chapter). In the real-world, the very basic idea of circuitry is this: that there is one force pushing the electrons around the circuit and another force pushing them back, resulting in a current that sits in the happy balance between the two.

I will confess now that circuitry was never my chosen subject in university, and while I will attempt to do it justice, there are thousands of details I've already omitted, but for the sake of arcane engineering, this simple idea will suffice. The other important fact I will ignore in developing this theory is Alternating Current.

Alternating Current (AC) comes from the movement of electrons back and forth; this is actually the far more interesting side of electricity in the real-world (in my humble opinion), allowing us to build filters for musical instruments, self correcting circuits, and many other complex effects. But as we will discuss later, there is no need for any understanding other than the simpler Direct Current (DC). With that, we can cover the second half of our brief tour of real circuitry.

Kirchhoff's Laws

These are some simple principles from real circuitry that I think will prove useful to us in the future development of the arcane circuitry system. This is where I find the analogy of rivers to be immensely helpful. The first law is that all current entering a junction must be equal to all current leaving a junction. In terms of our rivers, this makes perfect sense. If the river splits at a junction, the total amount of water coming out must be equivalent to the total amount of water coming in. Similarly, if two rivers meet and combine, they will also have the sum of water in = sum of water out:

$$\sum I_0 = \sum I_{out} \tag{2.2}$$

The symbol $\sum$ simply means 'the sum of' and will feature a lot in this book. Essentially put, we could write a simple version like $\sum_{n=0}^{3} n = 0+1+2+3 = 6$. In that example, we have included limits of n, but in cases where we are dealing with arbitrary amounts (like above), then we simply omit these from the notation, which suggests "Sum of however many you have."

The second law is that the sum of voltages must equal 0 across the circuit. When we add voltage using a battery, generator, or some other means, we consider that a positive voltage. When we lose voltage to components, we consider that a negative voltage. This means:

$$\sum V = 0 \tag{2.3}$$

$$\Rightarrow \sum V_{in} = \sum V_{out} \tag{2.4}$$

where $\sum V_{out}$ is the sum of voltages used in each component of the circuit and $\sum V_{in}$ is the sum of input sources of voltage. So, if we have a single component (a lamp for example), we use all of our voltage in that component. Looking at Ohm's Law, we can see that this can result in a dangerous or unwanted amount of current in our component. But if we add a resistor, then we will have some of the voltage used to push through that resistor which reduces the circuit's overall current. This is why we have components such as fuses, which will break if the current is much higher than is safe.

With all of this in mind, we are now, finally, able to start thinking about how we might make something analogous for the magic in 5e. Keep in mind that our main focus is not to recreate these laws and phenomena in 5e but instead use them as inspiration as we build around the known evidence of the rule book. Given their importance, we will also talk about each individual component's arcane cousin in their own subsection.

Arcane Charges

Unlike real-world voltages and currents, magic is incredibly discreet[1]. There is no fractional spell slot[2]; the requirement of the spell is either met or it isn't (or it is upcast, again by a discrete level). A lamp can be brighter when more current flows through it, but a fireball will always cost a 3rd level spell slot and no less. As such, we differ almost immediately from real circuitry in that our circuit is not a traditional flow of current as it is in a standard wire.

We choose to say that spell slots are not moved by a magic pressure that forces inherently magic particles in material to flow in a similar way to real-world electrons (though such a system might be a workable model for other systems, hells, maybe even a follow-up book to this one). Instead, we imagine our wire being a material that can carry a small fraction of a spell slot known as "Spell Slot Charges." You might be concerned given I just mentioned that "there is no fractional spell slot," but I hasten to add that that is in reference to casting; we cannot have half a fireball cast, but there is no reason to believe the energy itself cannot be moved in discrete packets that carry a fraction of the total amount of energy required. There are two possible methods of modelling these charges, either in a way similar to spell points, where they are identical regardless of level, and when enough pass to the caster (see Casters section), they will cast at their given level. Or in the model we will go with, the spell slot charges have their level data

[1] "Discrete" in physics means something is individual, distinct, and not continuous.

[2] Technically there are spell points, but these are less commonly seen and even then they're still discrete.

within them and cannot mix with other levels in the same wire. This leads to some interesting ideas, such as "Can we filter out different levelled charges and have them travel along the same wire for long distances then separate them out again?", while the other method would not require such filtering. However, the first method would also restrict the ability to up-cast spells by changing the source, and instead, you would have to change the caster.

Ultimately, this is irrelevant; there may be interesting implications of one system over the other that become clear in future research, but as things stand, it is simplest (and most in line with the most commonly used rules) to take spell slot charges at a given level spell slot. If you prefer the other system, it should be almost trivial to alter the following model to your liking.

We will have to assume that this arcane conductive material (or group of materials) exists. Its rarity, name[3], and physical properties are a decision for the GM as they are mostly unimportant for our work here where we can just say, "This material exists, and we can make wires and arcane components from it." In this material, the "Spell Slot Charges" can carry a finite fraction of any spell slot with them; they have no care for what level they are carrying, merely that they are carrying it. They will carry this fraction of a levelled charge through to the final spell casting component, which will do nothing until a spell slot's worth of charge has been deposited, at which point it will cast immediately (how it knows what spell to cast we will discuss in **Casters section**).

This might all seem super arbitrary: How many per foot of wire? How fast do they move? What fraction of a spell slot is carried? These are all fascinating questions that I think you should have an honest attempt at answering. That said, they can ultimately be arbitrarily decided. We can decide their speed and fractional spell slots semi-arbitrarily so long as they can follow the regular rules of 5e. Yet even there, we have some further arbitrariness. According to the rules, a single round takes 6 seconds, and in that, you and everyone else get your movement, action, bonus action, and potentially, reaction. For balance, it seems like a natural choice to say our spell slot charges move at such a speed and in such a density that in a single turn, they can cast one spell in a single action. Throughout, we will use T_A to notate the time chosen to take for an action; in many cases, we might choose $T_A = 1$ since that keeps the maths more simple, but ultimately, this decision is arbitrary so long as $T_A < 6$ seconds. If you do want more specific values (maybe you are one of those wonderfully technical players who are planning things beyond even my imagination; if you aren't that fussed about the technicality and maths, feel free to skip to the next section), we can simply calculate them.

In one action, we want a single spell to be cast; if we say the time for a spell of level $\mathcal{L}$ to be cast is T_L with the requirement $T_L \leq T_A < 6$ seconds, we can define the current I as:

$$I_0 = \frac{\mathcal{L}_{max}}{T_A} \tag{2.5}$$

where I_0 is the default current without any resistors in the circuit (discussed in the Resistors section), the units being "spell slot levels per second." $\mathcal{L}_{max}$ is the maximum level that can be cast (i.e., in 5e, we have $\mathcal{L}_{max} = 9$, but perhaps you would want to set it to $\mathcal{L}_{max} = 7$; for example, it matters not to the maths). We might also have $\mathcal{L}_{max}$ determined by the material used in the circuitry with only the rarest materials being able to cast 9th level spells; as such, we will just keep $\mathcal{L}_{max}$ as a variable throughout the theory and use $\mathcal{L}_{max} = 9$ for most 5e rules.

From this, we can then define the time needed to cast a spell by rearanging eq. (2.5):

$$T_L = \frac{\mathcal{L}}{I} \tag{2.6}$$

You'll notice here that if we then cast a spell with $\mathcal{L} = \mathcal{L}_{max}$, we have $T_L = \frac{\mathcal{L}_{max}}{(\mathcal{L}_{max}/T_A)} = T_A$ as expected[4]. More properly, this means that:

$$T_L = \frac{\mathcal{L}}{\mathcal{L}_{max}} T_A \tag{2.7}$$

If we say each carrier takes a fraction of a spell slot f (by default, $f = \frac{1}{1000}$ seems reasonable). We will need $\frac{1}{f}$ Spell Slot Carriers (SSCs) to carry a full spell slot over in T_L, that means there are $\frac{1}{f \times T_L}$ SSCs per second passing through a given part of the wire for a given spell slot level. Again, more generally:

$$\#\text{ of SSCs per Second} = \frac{1}{f \times T_L} = \frac{1}{f\frac{\mathcal{L}}{I}} = \frac{I}{f\mathcal{L}} \tag{2.8}$$

Though, these factors are not likely to come up in later theory. This is just a very technical exploration for those with the will and strength to indulge me in it.

When an SSC has dropped its fraction at the spell casting component, it will then carry on through the wire until it again reaches the battery or a grounding element. For most batteries, they will require a loop such that the battery finds new SSCs to charge while possible. My understanding of this would be that when charged by the battery with a fraction of spell slot's energy, the SSC will move through the wire (perhaps even directed by it), which will stop if the circuit has nowhere for it to go (e.g., a switch). In order for the current to stop flowing, there must be some counter to the movement induced by the battery. In real circuitry, this is our electron's repulsion. We do not want to limit arcane batteries by saying their

[3] Electrum does seem appropriate.

[4] Similarly, we are defining here that higher level spell slots take longer to cast. This will be important later, but I choose to justify it by saying it is because more powerful SSCs require more time to direct and control safely

switches must be immediately after the energising station, and so we must assign some level of mutual repulsive force to these charges that can overcome the force to move and hence stop the circuit. The battery will only be able to charge new SSCs passing through that are being forced to stop by the unmoving charges in front of them. One interesting consequence of this is that if the spells have some momentum, they will likely keep it, allowing them to further push into the resistance of unmoving charges. The consequences of too large a buildup in the circuit will be our fail state or circuit building and will be discussed in **Circuit Failure**.

This finally gives us the basis understanding. Spell Slot Carriers (SSCs) are found in certain rare materials that function as the foundational material for our arcane circuitry components. Batteries (which we will discuss in more detail in **Spell Slot Batteries**) are constantly trying to use stored spell slot energy to move SSCs that, in an open circuit, are resisted by the SSCs' mutual repulsion. When the circuit is closed, this force will dissapear and the charged SSCs will move through the circuit, pushing any uncharged SSCs along with them back to the battery. When these SSCs arrive at a spell slot component, they deposit their charge, and once a full spell slot charge is accumulated in the spell casting component, a spell is cast.

If, for whatever reason, a SSC escapes the circuit the energy is let off as bright light and heat (which may harm you at a certain level; we will discuss this more in **Rules**). This is a sharp and sudden decay of energy as the spell slot uses itself up in other ways so quickly, we treat it as effectively instantaneous.

This is barely *analogous* to real-world circuitry at best, and there's every chance that our attempt to form this allegorical system at all will lead to so many issues that fundamentally destroy it. I urge the reader to try and find them; consider this not to be taken as the written law of a god, which cannot and should not be broken. Instead, see it for what it is: A crackpot theory for fictitiously observed phenomena; if you can think of a better method and theory, then by all means do so.

Components

In this section, we will discuss each of the components necessary for basic arcane engineering. At the end, I will give a brief summary since there is already a lot of heavy theory, which will just end up in a simplified form anyway, and I want to give people the quickest route to playing with these systems.

Spell Slot Capacitors

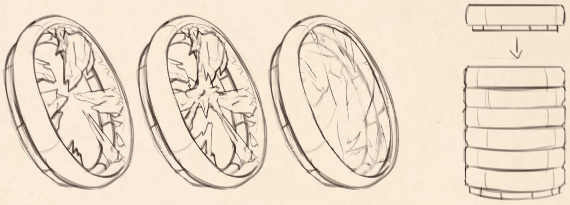


Figure 2.0.1: Example of an arcane capacitor being grown and then stacked to form a battery

Spell Slot Capacitors are the foundation of arcane batteries. In the real world, capacitors are not the foundation of batteries but instead two conductive plates separated by some distance with some insulating material between them (such as air). The insulation prevents charges from moving through the circuit and instead cause, a potential difference to build between the two plates. The capacitance of the resistor is defined using the charge it can hold "Q" and the potential difference "V":

$$C = \frac{Q}{V} \tag{2.9}$$

In a DC circuit, the charges will accumulate in one plate, and they will begin to resist the flow of new electrons onto the plate with their own negative charge, eventually building up enough repulsive force to push against the emf, forcing the current to stop entirely, which stops the buildup of more electrons and so an equilibrium is reached. If we then discharge this capacitor, we will quickly release this accumulated store of electrons. There is much more fascinating detail about how they interact with alternating current (AC) circuits and how they allow us to filter signal frequencies, but that will have to wait, as we have far more important magic material to cover.

In our case of arcane capacitors, are levelled spell slot holders. You might like to think of these as small crystals that glow when holding spell slot energy (rules for how these are charged are described in **Rules**). Capacitors are, like spell slots, levelled. A 1st level capacitor can **only** hold a 1st level spell slot, a 2nd level capacitor a 2nd level spell slot, and so on. Much like real-world capacitors, these are slow to charge but relatively fast to discharge. When an uncharged Spell Slot Carrier (SSC) is input into the capacitor, it is given some of the spell slot's energy, which forces it to continue moving in the circuit (and hence moving the rest of the SSCs in the circuit).

Most capacitors cannot hold a spell slot for an infinite amount of time. In fact, we can define their capacitance as it tells us how quickly spell energy within them will decay. Capacitors are defined by two numbers: Primary Capacitance Time "t_0" and Capacitance Decay "C" (this is quite different to real-world capacitors now, just to be clear). t_0 tells us how long the capacitor will remain stable for,

that is for a time of t_0 the capacitor will store the spell slot without decay. After t_0, however, the spell slot amount stored within the capacitor will be defined as:

$$S(t) = S_0 e^{-C(t-t_0)} \tag{2.10}$$

The eagle-eyed amongst you will notice that as soon as we are past t_0, this is not enough energy to cast a spell as $S_0 = 1$ (since we have only one spell slot per capacitor), and therefore $S(t) < 1 \ \forall \ t > t_0$, which means you cannot cast a full spell[5]. In order to solve this problem, arcane engineers will often opt to string together capacitors into "Arcane Batteries." I would suggest the default value for t_0 is 16 hours (i.e., a full day of being awake before a long rest).

One fun legendary item you can offer a player is the idea of a "Zero Capacitance Decay Capacitor" (ZCDC, even reading that gives chills of excitement, doesn't it?). If $C = 0$, then no matter how long it has been since the capacitor has been charged $S(t) = S_0 \forall t$. A 9th level ZCDC is the stuff only whispered by maddened wizards.

Spell Slot Batteries

These are simply a clustering of Spell Slot Capacitors to try and overcome pesky things like only being able to cast once and not being able to hold a spell slot over a 24-hour period. If we have two capacitors placed in our circuit one after the other, when empty charges pass through the empty capacitor, they will continue to the next; if that has energy, they will be able to pick it up from there. Therefore, two half charge capacitors are as good as one fully charged capacitor capable of casting a single spell. If we have a standardised battery where every component capacitor has equal C and t_0 values, then we can write the total number of spell slots as a sum of their individual values. Before t_0 (assuming all capacitors are charged), we can simply say $S = 1+1+1+... = N$ for an N capacitor battery. However, after t_0:

$$S = \sum_{i=0}^{N} e^{-C(t-t_0)} = Ne^{-X(t-t_0)} \tag{2.11}$$

where, we horrible people, we could make this incredibly complicated by considering the case where we charge each capacitor at a separate time "t_i." At which point, we would have to consider each of the batteries capacitors separately for whether they are 1 or have begun to decay and then sum the values of these decays. If you want to keep track of that, be my guest, and it will be more technically correct. Similarly, we might have capacitors each with different values of C and t_0, which would make our equation the terrifying:

$$S = \sum_{i=0}^{N} S_{0,i} e^{-C_i(t_i - t_{0,i})} \tag{2.12}$$

[5] $\forall$ is just a fancy maths way of writing "for all."
[6] Please.

In order to make this more convenient to play is to simply say a battery will lose all of its charge after a long rest (even though it isn't technically a limitation with the maths we have currently). Similarly, we can simplify things by limiting batteries to have identical capacitors within them (i.e., the same values of C and t_0).

There is much argument within the Wizards of the School of Arcane Engineering about whether it is better to charge every capacitor equally or to charge an equal number of capacitors as you are putting spell slots into the system. In reality, it doesn't really matter, which makes the arguments even more heated.

To recap, this means batteries have three parameters.

- N: The number of capacitors
- C: The Capacitance Decay of each capacitor
- t_0: The Primary Capacitance Time for each capacitor

As an Arcane Engineer, you are much more likely to encounter batteries than capacitors in your day to day, so for my sake, your fellow player's sake, and your GM's sake...just use the simple version[6].

Zeroth Level Batteries

If you have read some of my previous work, you'll know I have this irritating habit of calling cantrips "zeroth level spells." This will be no different, and you will never stop me. A zeroth level battery is quite simple; it draws on the natural magic energy in the world around us and passes zeroth level spell charges through the circuit. These can be used for casting as well as basic logic within circuits without using your own charged spell slot energy. Typically, the current of a zeroth level spell slot can simply be output into the air without causing much more than a spark as the Spell Slot Carriers dissipate and eventually lose their withheld energy; to account for this, these batteries are not filled with capacitors (as they draw the energy required as needed) and instead SSC rich materials such that even with the excess being dissipated into the air or ground, they will not run out. That said, most of this "grounding" effect is kept for logic gates, which we will discuss in **Logic Gates**, as the alternative will be to allow your zeroth level battery to continuously charge and run out of its reserves of SSCs much faster than anticipated and hence become useless. Most arcane engineers only need to swap their zeroth level batteries out once every few years; most carry enough replacements to last their lifetime.

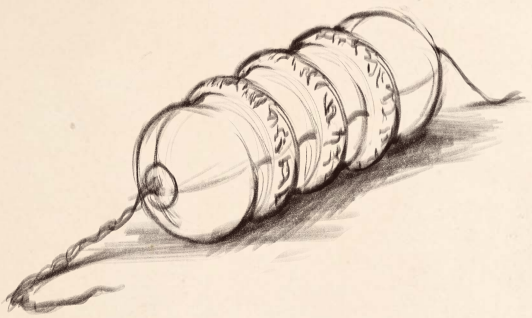


Figure 2.0.2: Example of an arcane Resistor

Resistors are fairly simple in their effect; they change the current of the circuit. In the real-world, this can be done by using a less conductive material (i.e., more force is required to push electrons through the resistor and hence more energy is used), to make the material thinner, which reduces the amount of electrons which can pass through at a given moment, or making the material longer, which means electrons have further to push in order to pass the current through.

In our wonderful world of arcane engineering, we only use the first option, special materials that do allow for our spell slot charge carriers to pass but at a much slower (or potentially faster) pace. While charges will enter the resistor at the normal pace, they will backup as they are slowly allowed through the resistor (the dangers of this will be discussed shortly). In **Arcane Charges**, we described the time taken to cast a spell of level L as:

$$T_L = \frac{\mathcal{L}}{I} \tag{2.13}$$

with I being the current of our Spell Slot Carriers. The default current is defined as:

$$I_0 = \frac{\mathcal{L}_{max}}{T_A} \tag{2.14}$$

where T_A is the time we choose an action to take (e.g. $T_A = 1$s) and $\mathcal{L}_{max}$ is our maximum level we can feasibly cast (typically $\mathcal{L}_{max} = 9$). This is chosen since we expect a $\mathcal{L}_{max}$ level spell to still be cast within an action (provided it isn't a ritual spell).

The new current after we add a resistor of resistance R to our circuit is:

$$I = \frac{I_0}{R} \tag{2.15}$$

This equation provides us with our definition of resistors. Our resistors slow down the current by a factor of R, and thus, the resistance of a material tells us by how much the spell slot carriers are slowed. Using eq. (2.13), we can substitute our new value for I:

$$T_L = \frac{\mathcal{L}}{\frac{I_0}{R}} = \frac{LR}{I_0} \tag{2.16}$$

Then, from eq. (2.14), we can substitute I_0:

$$T_L = \frac{1}{\mathcal{L}_{max}}(\mathcal{L}RT_A) \tag{2.17}$$

We call this equation **The Resistor Equation** as it tells us the time it will take to cast a spell of level L given our chosen T_A and the resistor R. This leads to the first obvious question: What is the maximum resistance we can add to any given circuit? Well, we can set a simple restriction that $T_L \leq T_A$. hence:

$$\begin{aligned} T_L &\leq T_A \\ \frac{1}{\mathcal{L}_{max}}(\mathcal{L}RT_A) &\leq T_A \\ \frac{\mathcal{L}R}{\mathcal{L}_{max}}T_A &\leq T_A \\ \frac{\mathcal{L}R}{\mathcal{L}_{max}} &\leq 1 \\ R &\leq \frac{\mathcal{L}_{max}}{\mathcal{L}} \end{aligned} \tag{2.18}$$

Note here, we are using T_A, as some spells require bonus actions to cast. You may wonder if that has any bearing on the spell as T_A will become T_{BA}. The answer is not simple, as bonus action spells still require an entire spell slot and this systems works by slowing the number of spell slot charges; thus we assume that the bonus action/action divide is not one of time and one of personal energy or mental capacity. Thus, we have, for all action and bonus action spells, the **Resistor Limit Equation**:

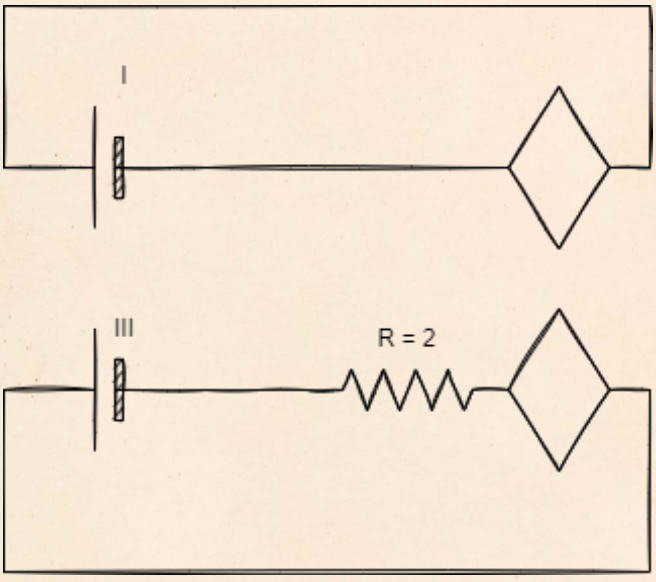
$$R \leq \frac{\mathcal{L}_{max}}{\mathcal{L}} \tag{2.19}$$

In simple terms, this means that the maximum resistor allowed for a given circuit relates to the spell level you intend to put through a circuit. If you will only cast spells of level 1 through, then $R \leq \frac{9}{1} \Rightarrow R \leq 9$; if I will pass levels 1 through 3 through my circuit then the maximum safe resistance is $R \leq \frac{9}{3} \Rightarrow R \leq 3$. If your resistance exceeds this inequality, then the Spell Slot Carriers building up in your circuit will become too dense with energy and cause a chaotic explosion or release of magic (see **Circuit Failure**). A buildup of level 9 spell slots is significantly more dangerous than level 1, and so it follows that lower level spells can withstand buildups more effectively. Specific implementations are discussed in the **Rules** chapter, but in a pure theory sense, I imagine it similar to wild magic or a powerful raw explosion of that spell level. This could be cleverly used if someone were devious enough (and brave enough) to try.

What if $R \leq 1$? The Spell Slot Carriers accelerate again. Since most spells cast are instantaneous, this does not usually matter, and spells that take longer to cast such as ritual spells cannot be performed

by circuits (as of yet, perhaps new research will allow for such things). One potential use is that if we slow our circuit down for some reason (perhaps before a split in wire), we can use a resistor with a resistance of 2; we could then return the current to normal frequency with a "resistor" or resistance 0.5. This provides an interesting idea of how we return charge carriers to the battery. At the moment, the best practice seems to be that the battery has them in such abundance that it does not matter the rate of return as the reserve is always vastly higher. This makes life simple. However, we could always add a restriction of resistors such that they are in fact "brackets" of sorts in our circuit, that for every resistor with resistance R, there must be an equal and opposite resistor that has resistance $\frac{1}{R}$. In such a scheme, the current will always return to 1, and the battery will have no net-loss of spell slot charge carriers. But I personally think that will over-complicate things too much for effectively the same result.

The primary use of resistors within arcane circuitry is to delay casting and time combinations of spells. For example, in the following diagram, you can see that we have two circuits that can be combined (as we'll see later) to begin at the same time. Using Equation (2.17), the first will cast spells with $T_L = \frac{1}{9}(1 \times 1 \times T_A) = \frac{1}{9}T_A$ while the second will cast within $T_L = \frac{3}{9}(3 \times 2 \times T_A) = 2T_A$ (i.e., twice as long as the first).



Series and Parallel Resistors

What if there is more than one resistor in the circuit? In real circuitry, we have two cases that will help inform us what to do with arcane engineering, and these are called "Series" and "Parallel." When resistors are in series they are happening one after the other along the same wire. In parallel, they are happening along different paths of different wires after a junction:

Figure 2.0.3: Two examples of how resistors may be set up. On the left, we have resistors in series, and on the right, we have resistors in parallel.

We can calculate the total resistance of N resistors in series as:

$$R_T = \sum_{i=0}^{N} R_i \tag{2.20}$$

which is just a fancy way of saying, "We add them all up." So in Figure 2.0.3, we have two resistors with resistance R_1 and R_2, respectively, their total resistance R_T will be $R_T = R_1 + R_2$. In parallel, things get slightly more complicated. We instead calculate the total resistance of N parallel resistors using:

$$\frac{1}{R_T} = \sum_{i=0}^{N} \frac{1}{R_i} \tag{2.21}$$

If there are series resistors within the parallel parts of the circuit, then we can add them up and treat them as a new resistor in our future calculations.

However, in arcane engineering, we deviate in some interesting ways due to our original choices of how Spell Slot Carriers are carried around the circuit (which tempts me even more to make a follow-up book for this exploring a more real-life similar model). Equation (2.15) tells us that $I = \frac{I_0}{R}$. If we imagine two resistors in series, the current going into the first will be I_0, and the current coming out will be $I_1 = \frac{I_0}{R_1}$, which will also be the current going into the second resistors. The current coming out of the second resistor will be:

$$I_2 = \frac{I_1}{R_2} = \frac{\frac{I_0}{R_1}}{R_2} = \frac{I_0}{R_1 R_2}$$

Or, more generally, for N resistors in series in an arcane circuit, the new resistance becomes the equivalent of a single resistor with total resistance R_T given by:

$$R_T = \Pi_{i=0}^{N} R_i \tag{2.22}$$

If you haven't seen $\Pi_{i=0}^{N}$ before, it is the multiplication equivalent of $\sum$, so $\Pi_{n=0}^{3} n = 0 \times 1 \times 2 \times 3 = 0$. The total resistance must still follow the rules of Equation (2.19), so be warned those who add too many resistors in series. The main use of this is to effectively create a new resistor with those which you already have.

If our resistors are in parallel, it is much more similar to the real-world case, but the interesting part for us is not the overall reduction in current but

how much goes to which parts of the junction. As we know from Kirchhoff's Laws, the current must split at a given junction such that $\sum I_0 = \sum I_{out}$. In the branch with the least resistance, we expect the most current to flow. The current in a given branch 'n' of parallel resistors (I_n) is defined as:

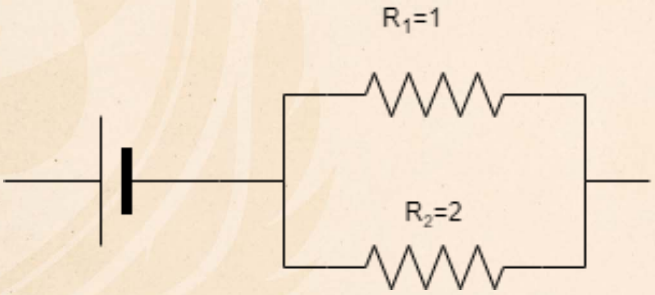
$$I_n = \frac{\frac{1}{R_n}}{\sum_i^N \frac{1}{R_i}} I_0 \tag{2.23}$$

where R_n is the resistance on branch n and $\sum_i^N \frac{1}{R_i}$ is the summation of 1 over each branch's resistance and I_0 is the current (after having been slowed by these resistors). The brilliant amongst you will notice our denominator looks suspiciously like eq. (2.21), and we can then say that the total resistance follows the same equation in arcane engineering and real-life. Thus, we have two restrictions to follow in parallel casting:

1. The resistance in individual branches must follow $R \leq \frac{\mathcal{L}_{max}}{L}$
2. The the total resistance given by $\frac{1}{R_T} = \sum_i^N \frac{1}{R_i}$ must also follow $R_T \leq \frac{\mathcal{L}_{max}}{L}$

Parallel Resistance Calculation Example

Consider the following example:



If we have level 1 spells, for example, then we have satisfied requirement one as both individual resistors are below $R = 9$. The overall resistance R_T is given by:

$$\begin{aligned}
\frac{1}{R_T} &= \sum_{i=1}^{2} \frac{1}{R_i} \\
\frac{1}{R_T} &= \frac{1}{R_1} + \frac{1}{R_2} \\
\frac{1}{R_T} &= \frac{1}{1} + \frac{1}{2} \\
\frac{1}{R_T} &= \frac{3}{2} \\
R_T &= \frac{2}{3}
\end{aligned} \tag{2.24}$$

And so, we pass the second requirement. In the example above, we can use eq. (2.23) to determine that the current passing through the lower branch (I_2) and the higher branch (I_1) will be:

$$\begin{aligned}
I_1 &= \frac{\frac{1}{1}}{\frac{1}{1} + \frac{1}{2}} I_0 = \frac{1}{\frac{3}{2}} I_0 = \frac{2}{3} I_0 \\
I_2 &= \frac{\frac{1}{2}}{\frac{1}{1} + \frac{1}{2}} I_0 = \frac{\frac{1}{2}}{\frac{3}{2}} I_0 = \frac{1}{3} I_0
\end{aligned} \tag{2.25}$$

We can then confirm that indeed after casting, the current will sum to I_0 as expected from Kirchhoff's Laws. We can also see then that the current through the first branch is twice that of the second and thus will cast twice in the time it takes to cast one spell in the lower branch. This is how we can time spells to a great degree of detail within our contraptions.

With that, we have finally detailed how resistors work in Arcane Engineering. These are fairly detailed rules and implementations we will attempt to simplify in **Rules**, but I want to highlight that these are in fact very difficult, and if you didn't quite understand it in parts or whole, that's perfectly understandable. Despite having gotten A's in courses directly about this exact subject, I still needed a lot of pen and paper to get my head around parts, so if you are also finding it a bit much, that's an entirely reasonable response.

One of the most interesting things about parallel resistance (in arcane engineering) is how unnecessary it often is; it might allow for some of the real clever clogs to do some truly ingenious things, but for most purposes of timing and casting, I found two separate circuits performed just as well while also being easier to verify they were valid by the rules.

Figure 2.0.4: Example of an arcane Inductor

This is the last major component we will talk about but certainly one of the more important. In the real-world, inductors rely on the fundamental relationship between electricity and magnetism. Every time an electric charge moves, it generates a magnetic field in a circular arc around itself. This behaviour is very accurately modeled by most right hands. If you form a thumbs-up sign with your thumb pointing straight up and your fingers closed into a fist, you can think of your thumb as representing the direction of current (which is, by a frustrating convention, the direction of positive charge flow and hence the opposite of electron flow direction), and your fingers will represent the circular magnetic field these moving charges have created. This rule is, of course, reciprocal as well, as a moving magnetic field can generate electric current (an incredibly helpful fact for electricity generation). These laws were codified with Maxwell's Laws of electromagnetism and while they are incredibly fascinating, I might have to leave their exploration for another time. The key is: Electricity and magnetism are intrinsically linked. This leads to all sorts of fun physics, such as the speed of light (Electromagnetic Radiation), energy generation, and modern electrical instruments.

In an inductor, we coil wire together such that our electrons move in a circular motion, and this creates a magnetic field. When we first pass a current through our inductor, the change in current causes the magnetic field to similarly change, which itself causes a voltage (or electromotive force) to push against the flowing electrons. Specifically, according to Faraday's Law of Induction[7], the change in magnetic flux Φ_B produces a voltage:

$$V = \frac{d\Phi_B}{dt} \tag{2.26}$$

where flux is just the physics way of saying "How much of this field is passing through a given area." The term $\frac{d\Phi_B}{dt}$ simply means "The change in the magnetic flux with respect to time." This may all seem overly complex, but I assure you that these formal and nuanced equations and definitions can help us reveal the strange perplexity of our universe, but for our purposes we will keep it relatively simplified in necessary understanding.

Because of this negative voltage (from eq. (2.26)), the inductor actually works against the forces pushing the electrons in the battery and thus resists the change in current. How much this inductor resists the change is defined by its inductance: $L = \frac{\Phi_B}{I}$. Rearranging this a little and plugging into eq. (2.26), we get:

$$V = \frac{d}{dt}(LI) = -L\frac{dI}{dt} \tag{2.27}$$

where we are able to move L out of the derivative $\frac{d}{dt}$ since it doesn't change with time. If you remember from earlier definitions, V being negative shows that it is going *against* the emf of the battery, resulting in a direct relationship between the voltage resisting and the change in current. However, since this induced voltage slows down, the change in current over time $\frac{dI}{dt}$ also reduces, which reduces the magnetic flux and then the voltage, which reduces the resistance to the current such that it can increase again (but slower than before). Eventually, the current will reach a steady value and with no more change in the current $V = -L \times 0 = 0$. At this stage, there is a steady magnetic field running through and around the coils of the wire and no more opposing voltage. This works in the reverse as well now, and if the current shuts off and begins to reduce, then the inductor will form a positive voltage and oppose that change as well by generating a voltage as current decreases.

One of the really cool things we can do with this is transfer energy from one inductor to another. As we (well, Maxwell) discussed earlier, electricity and magnetism are intrinsically combined, and so placing another inductor near one with a steady magnetic field can *induce* a current in the other inductor, allowing the transfer of electric energy through the magnetic fields! We call these systems "transformers", and the exact voltage transferred is defined as:

$$V_2 = k\sqrt{\frac{L_2}{L_1}}V_1 \tag{2.28}$$

Like so many things in physics, I have ignored the three or so pages of derivation to get to this result, but I am personally a big fan of complex derivations that result, in outstandingly simple equations. The

[7]While it isn't always good practice to cite Wikipedia, I can highly recommend googling terms like these if you are more curious, and often for physics, the Wikipedia page is reliable. If in doubt, you can check the sources.

value of k is the coefficient of coupling between the coils, but for our sake, we will say k=1 (i.e., we did it perfectly, also known as an "Ideal transformer"). We can even reduce this further since $\frac{L_2}{L_1} \approx \frac{N_2}{N_1}^2$, so we can rewrite eq. (2.28) in terms of N_1 and N_2 (the number of loops in each inductor):

$$V_2 = \frac{N_2}{N_1} V_1 \tag{2.29}$$

which I think is just very tidy.

So what's the point of my long rant? How can we adapt this into arcane engineering using the theories we've already built? Inductors in the real-world heavily rely on this electromagnetic connection that we simply do not have in magic. Instead, I posit something somewhat analogous: The moving spell charge causes a small ripple in the arcane field-space (commonly known as the weave, though I have some theories that these may be separate concepts entirely), which permeates all reality and is utilised by spell casters and arcane circuitry alike. Similar to the real-world, if we coil our arcane wires, we see this perturbation in the magic field build up over time, initially resistant due to the tension inherent to the field (as discussed in the Theory of Magic) but gradually becoming easier as a more stable field grows. This field will then, once stability is reached, resist changes in the circuits state and allow a spell (that is receptive to such things) to maintain itself for a given time unless the circuit itself undergoes enough trauma to rupture the stability of this field. The inductance here will then refer to how resilient the inductor is and what level of spell it can effectively use.

Or in less condescending language: **circuit concentration**. For the sake of balance, we restrict inductors to only be able to function with spell slot levels at or below their inductance.

The presence of an inductor will allow the casting of concentration spells through circuits. I must admit, I find this justification a little too hand wavey, but it is an important aspect of spells, and I do think the idea works. In universe, feel free to consider this a developing theory from an eccentric academic wizard. In reality, you can call it what it is: A simple justification for a necessary component of spellcasting by a person who takes ttrpgs slightly too seriously.

The second important aspect of capacitors though is their transformer capabilities. Here, I propose a very simple relationship to govern the effectiveness of two inductors:

$$\mathcal{L}_2 = \epsilon \mathcal{L}_1 \tag{2.30}$$

where $\mathcal{L}_1$ is the spell slot level input to the transformer and $\mathcal{L}_2$ is the spell slot level after transformation. ϵ is the transformer constant defined by the inductance of the two inductors:

$$\epsilon = \frac{L_2}{L_1} \tag{2.31}$$

This scheme means we could effectively transform a level 4 spell slot into a level 2 spell slot using a level 4 and level 2 inductor in seperated circuits. This maths definition can be rewritten slightly to show that:

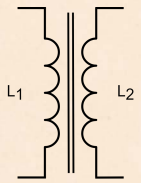
$$\frac{\mathcal{L}_2}{\mathcal{L}_1} = \frac{L_2}{L_1} \tag{2.32}$$

which means our transformer rule can simply be put as transforming from circuit 1 to circuit 2. You simply use the inductors at the level in which you intend to use in the second circuit to transform from the level in the first using an inductor of the same level.

This is how we might up or down-cast spells. I have some debate about whether it should be allowed to up-cast spell slots and it seems for balance's sake, we must limit this to only downgrade spell slots. Or more plainly:

$$L_2 \leq L_1 \Rightarrow \mathcal{L}_2 \leq \mathcal{L}_1 \tag{2.33}$$

The circuit notation for a transformer is two parallel inductors with parallel lines between them (since we assume they are ideal):



With that, we now have our large and major components at hand. Now we may look at the components that really truly unlock the creativity inherent to arcane engineering.

Logic Gates

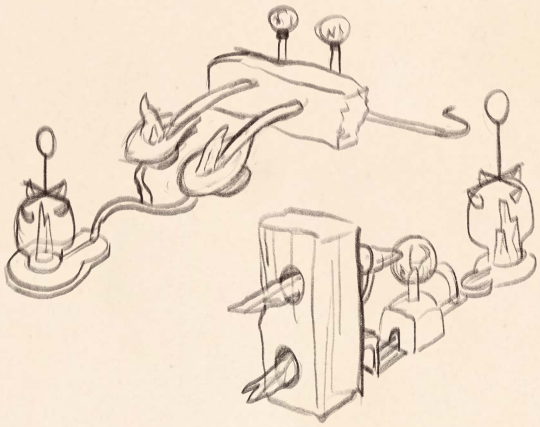


Figure 2.0.5: Example of arcane Logic gates.

Luckily for us, the similarities between the arcane and real Logic gates will be immense. There will be some differences later on, but for now, we will focus on the broad strokes.

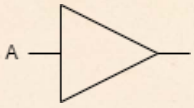
Logic gates take one or more binary inputs. These are inputs that are either on (1) or off (0) and

output a single binary output. These can form incredibly complex digital circuits, but they are also exceptionally useful for forming more nuanced arcane circuits. Here, I will cover the simplest Logic gates and cover their "logic tables" before including some extra considerations for arcane circuitry.

There are two gates that take in a single input, the buffer, and the NOT. The buffer gate simply returns the input while the NOT gate returns the opposite of the input. To show how gates operate, we can use something called a "logic table" that gives us all the necessary information for how these systems will operate. They have two broad columns: input and output. The output column shows us whether the output will be 0 or 1 for a given output. The input columns show us the value for each input node, and we permutate through all possible combinations of inputs.

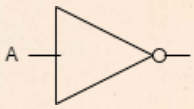
The logic table and symbol for the buffer is:

Input A	Output
0	0
1	1



Some gates (such as NOT) will have a circle on the right hand side of their regular symbol, and this means we invert the normal output. The NOT gate is the inversion of the buffer gate:

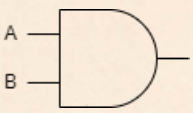
Input A	Output
0	1
1	0



To justify this in our system we will say the not gate can only take 0th level inputs and acts essentially as a 0th level battery. If it receives a signal it ejects the input, if it does not receive a signal it sends 0th level SSCs.

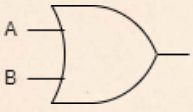
For more complex gates, we typically have two inputs, A and B. For example, the AND gate checks if both inputs are on, and if they are, then it returns 1; otherwise, it returns 0.

Input A	Input B	Output
0	0	0
0	1	0
1	0	0
1	1	1



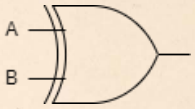
which we can also invert to NAND, which will simply turn a 1 in the output column into 0 and 0 to 1 (i.e., it will remain on unless both gates are on). Finally, we also have the OR and the XOR gates:

Input A	Input B	Output
0	0	0
0	1	1
1	0	1
1	1	1



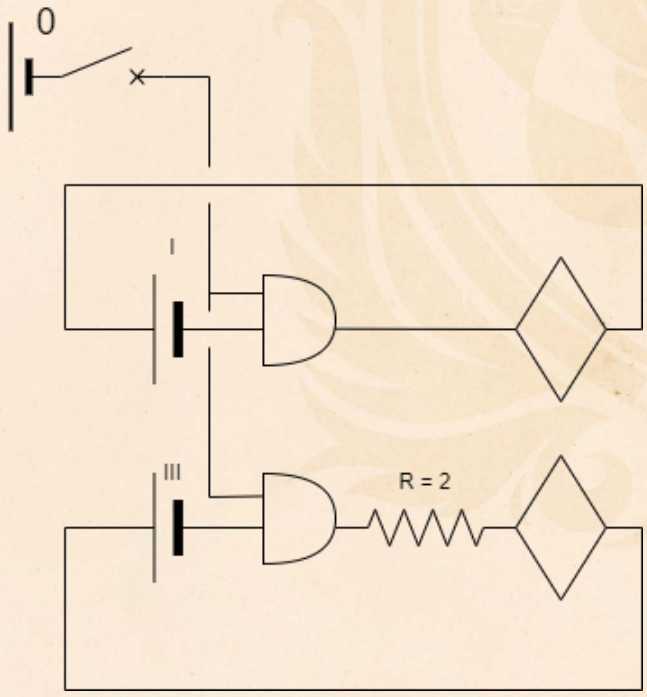
[8]Any effect from Prestidigitation seems reasonable

Input A	Input B	Output
0	0	0
0	1	1
1	0	1
1	1	0



So, what do we need to add to make this compatible with arcane engineering? Well, it is quite simple. When using logic gates, at least one of the inputs to any gates must be connected to 0th level batteries, and by convention, if a non-0th level Spell Slot Carrier is passing through, it will be to the B input, which will then be allowed to pass through the output. The unused 0th level Spell Slot Carriers will be flushed from the logic gate, producing a defuse but harmless magic effect[8]. This is a minor but crucial change as a dangerously under-qualified arcane engineer might accidentally connect his non-0 SSCs to the A input and cause a (slightly directed) blast of uncontrolled magic energy, and who would ever want to do that?

These are simple but incredibly powerful systems. For example, if we look at the arcane circuit in Chapter 2 we can use logic gates to combine the two circuits to a single switch:



When the switch is closed, the 0th level Spell Slot Carriers will pass to the two AND gates, allowing the first and third level spell carriers to pass through the circuit as intended. This is a very basic example, but hopefully it is now explaining some of the complexities.

Standard Casters

Figure 2.0.6: An example of an Arcane Caster in a protective casing

Throughout this entire book, I have been desperately avoiding talking about what is actually casting the magic. That time is over, and now we must finally discuss the spell casting component. There are two types: those which cast predefined spells (which we will discuss in this section) and those which cast customised damage spells (the next section).

Standardised spell casters are small arcane focuses (such as crystals) through which you have spent a considerable time (approximately one hour for each level of the spell) encoding your understanding of the spell through such that they can cast it without direct guidance. This encoding requires your own detailed understanding of a spell and thus is limited to spells known to the caster. Similarly, this in-depth understanding of a spell means that arcane engineering is limited to wizards. These focuses will "remember" these spells until they are destroyed or decoded (which takes an equivalent amount of time as to encode) and will cast the spell given to them every time they receive enough power; this is either through the arcane circuitry as discussed or through the caster themselves (though that seems unlikely as the caster could simply cast the spell themselves). In circuits, we notate these using a diamond shape (to represent the common choice of crystal material by arcane engineers who regularly choose coloured crystals that follow a convention of colour to school of magic). This isn't necessary, of course, and is just convention, and modern magical research suggests the schools of magic are themselves arbitrary. Still, the convention is:

- Conjuration: Yellow
- Necromancy: Green
- Evocation: Maroon
- Abjuration: Indigo
- Transmutation: Orange
- Divination: Cyan
- Enchantment: Pink
- Illusion: Purple

There are, of course, different conventions as some arcane engineers prefer to personalise their casters to the spell. Some carve the spell rune into the stone itself, others choose meaningful materials to them, and some even use non-conventional or misleading materials as a trap for those unsuspecting.

The point is: you can do it however you like, but I will judge you for not using the same convention as me (just like real science).

Custom Casters

These are marginally more complicated than the standard casters but not by much. Instead of presenting the stone with the inner workings of a known spell, you may opt to instead create your own. As you become a more capable wizard, you will learn new ways of modifying custom casters to include new components. The different attributes you may customise are the:

- Spell Level
- Area Type
- Damage Type
- Range

As these spells are home-crafted, they are not classified into schools of magic (unless the creator insists). These spells are generally weaker than the well researched standards but can form useful custom outcomes. Once created, these can be disassembled and remade.

Spell Level

This is fairly simple: you can select a level up to and including your highest level spell slot.

Damage Type

A simple selection of either Acid, Bludgeoning, Cold, Fire, Force, Lightning, Necrotic, Poison, Psychic, Radiant, Slashing, or Thunder damage.

Area Type

Each level of spell can have a single target or an area of effect no greater than the values presented in the table below:

Level	Cylinder	Cone	Cube	Line	Sphere
0	(5, 10)	5	5	15	5
1	(10, 20)	15	15	30	10
2	(10, 20)	20	15	30	10
3	(20 30)	20	20	60	20
4	(20 30)	30	20	60	20
5	(20 30)	30	20	60	20
6	(30 40)	60	30	90	30
7	(30 40)	60	30	90	30
8	(30, 40)	60	30	90	30
9	(40 60)	60	60	120	40

Table 2.1: Area Types allowed in custom casters for each given level. Cylinder values are given in form (radius, height), Sphere values represent the radius, and all values are in units of feet.

Range

The range is similarly defined as being one of the following options:

Level	Range
0	Touch/Self/<60ft
1	Touch/Self/<60ft
2	Touch/Self/<60ft
3	Touch/Self/<90ft
4	Touch/Self/<90ft
5	Touch/Self/<90ft
6	Touch/Self/<120ft
7	Touch/Self/<120ft
8	Touch/Self/<120ft
9	Touch/Self/<150ft

Predicted Damage Table

The predicted damage per damage type from the Theory of Magic given in the tables at the top of the next page.

Miscellaneous Components

I feel it worth mentioning that in your circuits you may wish to include something that hasn't been added here. I think, provided they do not produce a magic effect, that should be fine. For example, a button for closing the circuit, levers, lights, etc. You may also invent components like "magic field detector," which could be used to detect incoming magic effects. These are up to the discretion of your GM, but I believe that they could serve a crucial and fun aspect to creating your own circuits.

Another interesting idea is transmitter and receiver components that may allow you to, for example, use a receiver to trace the strength of a signal from another circuit's transmitter, giving you a rough estimate of its direction, which gets stronger as you approach.

Recap of Components and Rules

Spell Slot Carriers

Spell Slot Carriers (SSCs) can hold a finite fraction of a spell slot's energy and are found in magically potent materials such as crystals. They are able to pass through certain magic conductors like electrum and have a slight repulsive force to each other, such that if the circuit is closed, they will stop moving. When given a finite fraction of a spell slot's energy by a capacitor, they will begin to move if they can. When they reach a caster, they deposite this small fraction to a the caster's larger reserve.

Capacitors

Capacitors can hold a single spell slot in them. When SSCs pass through them, they give them a fraction of that spell slot to carry forwards. Capacitors lose their charge after a long rest (see above for details) and must be recharged after.

Batteries

Capacitors can be stacked together to form batteries that hold multiple spell slots of the same level. The battery's level reflects what spell slot it can hold.

Resistors

Resistors slow current down according to their resistance: $I = \frac{I_0}{R}$ which results in the time to cast a levelled spell being defined as: $T_L = \frac{1}{\mathcal{L}_{max}}(\mathcal{L}RT_A)$ with $\mathcal{L}_{max}$ being the maxmium spell level and T_A begin an arbitrary time taken for an action. Their primary function is to allow for the timing of seperate spells in the same combination of circuits

The total resistance along any given path must satisfy the inequality: $R \leq \frac{\mathcal{L}_{max}}{\mathcal{L}}$.

Series resistors can have their total resistance calculated by multiplying them, and parallel resistors can be calculated as one over the sum of one over each individual resistor.

Inductors

Inductors allow for spell concentration and down-casting. Their level determines the level of spell they can use to concentrate with, and to downcast from two levels, you simply place two inductors of those levels near each other (i.e., to go from level 9 to 3 you would have two inductors of levels 9 and 3 near each other, though such a waste of a 9th level spell should be discouraged).

Level	Radiant	Poison	Piercing	Fire	Slashing	Cold
0	1d8	1d8	1d8	1d8	1d8	1d8
1	1d10	1d12	1d8	1d8	1d8	1d12
2	2d8	2d10	2d6	2d8	2d8	2d10
3	3d8	3d8	2d10	2d12	4d6	3d8
4	4d6	4d8	3d8	3d10	5d6	4d8
5	5d6	6d6	4d8	6d6	7d6	5d8
6	5d8	7d6	5d8	7d6	8d6	7d6
7	7d6	8d6	6d8	8d6	10d6	9d6
8	8d6	7d8	9d6	10d6	11d6	10d6
9	7d8	8d8	6d10	11d6	13d6	11d6

Level	Force	Psychic	Thunder	Acid	Necrotic	Bludgeoning	Lightning
0	1d8	1d8	1d10	1d8	1d8	1d6	1d10
1	1d12	2d6	2d8	2d6	1d10	1d10	2d8
2	2d10	2d10	3d6	2d10	2d8	2d8	3d6
3	3d10	3d8	3d8	4d6	3d8	3d8	3d10
4	6d6	5d6	4d8	4d8	4d8	5d6	4d8
5	7d6	6d6	6d6	5d8	5d8	6d6	5d8
6	6d8	5d8	5d8	7d6	6d8	7d6	6d8
7	6d10	7d6	6d8	9d6	7d8	8d6	9d6
8	8d8	9d6	8d6	10d6	8d8	7d8	10d6
9	9d8	7d8	7d8	11d6	9d8	8d8	8d8

Logic Gates

Logic Gates behave very similarly to real logic gates taking in a number of inputs and a single output. One of the inputs will continue through the gate while the other will be ejected. It is **vital** that arcane engineers have the ejected input be a level 0 battery as otherwise it can be dangerous (see later).

Casters

Casters have a spell assigned to them by the circuit designer and will cast a spell as soon as enough energy has been given to them. You can use predetermined spells and (if necessary) preset the choices for casting as well as building your own caster with equipment that scale with your own expertise.

Miscellaneous Components

Your GM should allow you to have some level of custom components within reason. Though, if you are abusing this, they have my full permission to have the component break and never ever reappear again.

Chapter 3: Rules

There are a few guiding principles with this rules section that I should outline. The main reason for doing so is so that you can modify and implement these rules to fit the *spirit* of the rules if the actual implementation here does not balance well in your game. As ever, we should consider the golden rule of ttrpgs: "The GM has ultimate power, and they can remove/modify/add any rule they choose at any time provided such changes enhance the gameplay experience for the players." This can be a difficult line to walk; I know I struggle between "Is this monster winning because it's balanced or am I just salty because they delayed the session three times in a row?" So, with the golden rule in mind, here is the spirit of my rules.

1. Arcane Engineers should *feel*[1] like playing a wizard subclass. It is specifically designed with the level of technical and specialised knowledge that defines wizards, and an arcane engineer should feel like a specialised wizard.

2. The rules should not be restricted by the theory if the theory is inhibiting fun. This was partially discussed in **Spell Slot Batteries** where we talked about the simple and complex rules implementations (e.g. batteries). While one may be more technically accurate if that isn't fun for you or your table (and I imagine it isn't), then we shouldn't be restricted by it.

3. Circuit construction rules should be simple in a way a non-expert can understand. Here, non-expert means someone who hasn't read this book (which makes you an expert, congrats). There is a strong chance that if you use this as a GM or a player, you will be doing so with people who don't share your enthusiasm for this sort of thing. In order to keep things clear, fair, and fun, we should do our best to give clear instructions that a non-expert can check.

4. The Arcane Engineer should not make other wizard classes obsolete and should have flaws and failings, things they cannot do that another wizard might.

With all that said and done...let's have a go. This section will mostly be discussing the rules we are implementing and why they have been chosen and how they relate to the theory. At the end, we will make a cheat sheet for GMs and players which should include all necessary rules for playing an arcane engineer. If I do my job right, it should cover a simple A4 page, but knowing me, it will be at least two.

[1] Already starting strong with vague language

Circuit Building

Circuit building takes time, tools, components, and expertise. Without considering other abilities, adding or removing a single component to a circuit takes half an hour on top of the base time required to build a circuit of that size. Only an Arcane Engineer may build circuits.

You may wish to have your circuit on an object, which is, of course, fine. There will be some restrictions, though. You cannot modify the underlying object on which there is an existing circuit without breaking the circuitry itself, and so you must disassemble the circuit before modifying. There are also considerations about the size of the underlying object.

Each component is approximately 1cm (4/10ths of an inch) in length, and a quarter of that in width and height. Creating circuits on larger objects makes them sturdier and capable of holding more components, but will take more time accourding to:

Size	# of Components	HP	Construction Time (hours)
Tiny	5	2	0.5
Small	10	5	1
Medium	20	9	4
Large	40	13	16
Huge	80	3 HP per component	64
Gargantuan	160+	3 HP per component	256

Table 3.1: Table showing the different construction rules and properties of circuits with different sizes.

Number of Circuits

Arcane circuits interfere with each other when charged. The maximum number of charged circuits anyone can have on their person at any given time is equal to the intelligence modifier of their creator as you find more ingenious ways to insulate the circuits from each other. If there are two arcane engineers then the maximum number is equal to the largest intelligence modifier but they do not stack.

Building Casters

In order to have a caster that can cast a specific spell, you must spend one hour concentrating on the caster to imbue it with the understanding you have of the spell. Some arcane engineers do this by carving onto the crystal directly, and others will write runes around it, others will simply sit in silence. Once a caster has been set to a specific spell, it will take one hour to remove it such that it can be reused.

Circuit Damage and Repair

Of course, your circuits may incur some damage during your adventures. The circuit has a AC of 10, and when the circuit takes damage its creator must roll an intelligence saving throw to test the robustness of the creation. On a successful saving throw the circuit takes no damage, on a failure it takes full damage. A Variant rule to this might be that the AC is determined by size (Tiny: 19, Small: 16, Medium: 13, Large: 10, Huge: 7, Gargantuan: 4), use whichever suits your table best. The total hit points of your circuit decided by its size (table 3.1). If the circuit falls below 0HP, it will cease functioning, and if its HP falls to negative values below or equal to its maximum HP, then the circuit cannot be repaired.

To repair circuitry, you must have the arcane engineer subclass and half the material cost required to create the circuit. It takes one quarter of an hour to repair each component. Circuits are not creatures and cannot be healed by healing magic, health potions, or other medical checks. Similarly, the mending spell cannot be used to repair arcane components as the spell cannot restore magic to an object.

Charging Circuits

Charging a battery requires a full turn per spell slot. This is so that out of combat you can effectively allocate charges as you please; it makes sense within the theory and allows you to cast spell slots through a circuit if the battery has run dry but you still have some spare. To maintain balance, we require that doing so takes your entire turn (movement, action, bonus action, and reaction) to do so. As a rule of thumb, the battery will lose all charge after a long rest but there are magic items that do not have this decay or lessen it so that they only half by the time a long rest is taken, or even do not decay at all (see **Spell Slot Batteries**). With the arcane engineering subclass, at the appropriate level, you may, as an action, dump the entirety of the energy of your battery as a single attack doing 1d6 per level for each spell slot in a 15 foot cone (details on the attack in the next section). This means two 3rd level spell slots would do $6d6$ damage. This effect will be fairly chaotic and so you should roll for the type of damage it does using a d12 with the following table:

d12	Damage Type
1	Acid
2	Bludgeoning
3	Cold
4	Fire
5	Force
6	Lightning
7	Necrotic
8	Poison
9	Psychic
10	Radiant
11	Slashing
12	Thunder

Table 3.2: Damage Type table for a battery dump attack.

Anyone/anything can activate and use an arcane circuit, but only an Arcane Engineer can charge them since it requires technical knowledge of the components to do so safely.

Time Delays and Duration

Detailed Out of Combat Rules

Time delays are crucial for so many of the brilliant (and terrible) contraptions an Arcane Engineer might dream up. The main issue with this in 5e is that time falls into two, distinct states: Non-combat and combat. We'll begin with the simpler non-combat implementation.

As discussed previously, the time to cast a spell of a given level "L" is given by eq. (2.17) which is:

$$T_L = \frac{1}{\mathcal{L}_{max}}(LRT_A) \tag{3.1}$$

Where $\mathcal{L}_{max}$ is the maximum castable spell level (9 in our case[2], R is the total resistance before the caster, and T_A is the time it takes to take an action. Since T_A is somewhat arbitrary, we leave it in the equation as a reference time that can be tweaked by the GM. Personally, I think $T_A = 3$ is the best value, but this will vary with other tables. The calculation of R is a little more complicated, as discussed in **Resistors**, but to recap, we use eq. (2.22) for series resistors (resistors that are one after the other) and eq. (2.21) for parallel resistors (if the wire splits and rejoins before the caster).

In the below example (which will probably be more complicated than anything you should make), there are two casters and four resistors. In order to calculate T_L for each spell caster, we need the total resistance of their path.

[2]I was toying with the idea that this should be your maximum spell level *you* can cast such that as you gain higher spell slots your circuits become marginally faster, but given that this effect is already fractions of a second, it seems arbitrary and a needless complication.

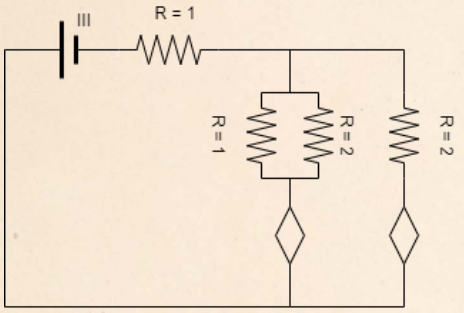


Figure 3.0.1: An example complex circuit for casting two level 3 spells

The first, simpler, path is shown below, where we follow only series resistors:

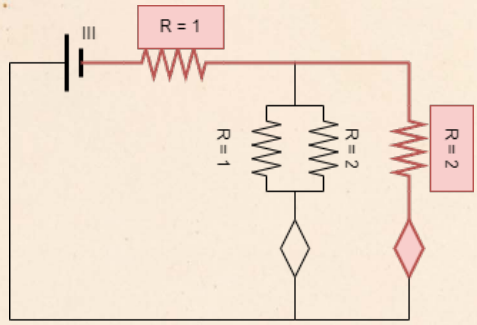


Figure 3.0.2: The same diagram as fig. 3.0.1 with the simplest spell casting path highlighted.

On this path, we have two resistors, one of resistance $R_1 = 1$ and one with resistance $R_2 = 2$. To calculate the total resistance according to eq. (2.22) we simply have $R_T = \Pi_{i=0}^{N} R_i = R_1 \times R_2 = 1 \times 2 = 2$, thus $T_{L1} = \frac{1}{9}(3 \times 2 \times T_A) = \frac{6}{9}T_A = \frac{2}{3}T_A$.

In the second path, we have three resistors:

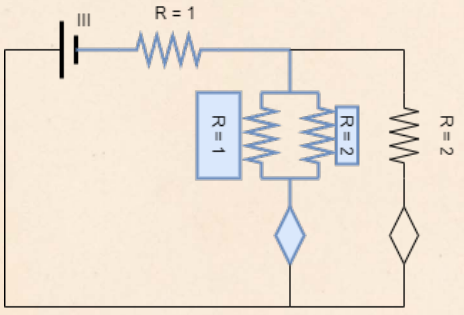


Figure 3.0.3: The same diagram as fig. 3.0.1 with the more complex spell casting path highlighted.

While this might seem complex at first, we can break the problem down. First, we will calculate the resistance after the first split (i.e., across the two parallel resistors). As discussed previously in Equation (2.21), we can calculate this total resistance (R_P) as:

$$\begin{aligned} \frac{1}{R_P} &= \frac{1}{R_1} + \frac{1}{R_2} \\ \frac{1}{R_P} &= \frac{1}{1} + \frac{1}{2} \\ \frac{1}{R_P} &= \frac{3}{2} \\ R_P &= \frac{2}{3} \end{aligned} \tag{3.2}$$

We can then combine this resistance with the first resistor (before the first split, just after the battery) the same as before: $R_{T2} = 1 \times \frac{2}{3} = \frac{2}{3}$ and thus $T_{L2} = \frac{1}{9}(3 \times \frac{2}{3} \times T_A) = \frac{2}{9}T_A$.

It is important to note here that per our definition of resistance, a resistor of value $R = 1$ has no effect on the current. Regardless, we can see that the more complex path will cast first while the simpler one will cast second. If we use my proposed value of T_A we get $T_{L1} = 2s$ and $T_{L2} = \frac{2}{3}s$.

An Aside on Total Resistance of Example

As discussed in **Resistors** by Equation (2.19), there is a limit to our total circuit resistance we must account for. The total resistance here is the sum of the resistances in the two vertical paths, as previously calculated the resistance in the left path is $R_P = \frac{2}{3}$ and the resistance in the second is simply 2. We combine these using eq. (2.21):

$$\begin{aligned} \frac{1}{R_T} &= \frac{1}{R_1} + \frac{1}{R_P} \\ \frac{1}{R_T} &= \frac{1}{2} + \frac{3}{2} \\ R_T &= \frac{1}{2} \end{aligned} \tag{3.3}$$

Since $\frac{\mathcal{L}_{max}}{L}$ is 3 we satisfy $R_T \leq \frac{\mathcal{L}_{max}}{L}$.

Simplified Rules

The above is...rather complicated if you're planning to use this in any given scenario. While I think they are better and if you're willing to put in the effort to calculate specific timings, your GM should allow it, however, no one wants the game to come to a screeching halt because you need to run a quick calculation. The simpler form of the rules that you will be able to simply calculate (even if it isn't *technically* correct) is that the time delay out of combat for each caster is a number of seconds equal to the product of resistor levels before it. Obviously this means that you can't use parallel resistors, but it does simplify everything to a more manageable degree.

In Combat Rules

What about during combat? Well, now we have covered the basics, this is but a small modification

that accounts for initiative. We simply calculate the time as we have before, but this time, we round to a whole integer. We say the spell is cast at the initiative order T_L after the initiative step it was activated. Circuits always go at the end of that initiative's order (i.e., creatures and players go first), and if there are two circuits on the same initiative value, then the one that was activated first will go first. So, in our example, if we were in combat and activate the circuit on our turn, the shorter delay ($T_L = \frac{2}{3}$) will happen on the initiative step immediately following our turn, and the longer delay ($T_L = 2$) will happen two steps after our turn. This might sound counter-intuitive and strange, and that's because it is. By my understanding of the base rules an entire round in 5e combat lasts 6 seconds. Regardless of if there are thousands of combatants or two, they will take 6 seconds to all take their turns; this isn't an exact science and so this rule-set, while not technically the most accurate, allows for Arcane engineers to plan their turns with their delayed circuits. **Similar to the out of combat scenario, we can simplify this to be a position after you in initiative equal to the product of resistor levels before each casting component**.

I think the simplified rules will work well for most tables, but you may wish to talk to your GM about implementing components such as timers or fuses to allow for longer delays.

Cost of Components and Component Crafting

Like all magic items and necessary equipment, this comes down to your GM's discretion, should they think you are overpowered, they may restrict the supply. If you ask nicely and they feel you have earned it, the supply might become more generous. Personally, I think components should be broken into levelled kits, each costing approximately double of the last. These will contain necessary components for a given level and their rarity determines the contents for said level, this rarity similarly increases the cost. A nice and simple method might be to have a price per kit and a price per rarity, and to simply add them together to get the final price of a kit of a given level and a given rarity. In the following table I will give an example price guide for this (but you are more than welcome to change this to suit your world and players).

This is, obviously not perfect and I think a little bit restrictive, so your players should of course also be able to buy components individually. For such things, the above table can be a guide for their rarity and cost. In general, higher level components should cost exponentially more than their lower level versions, and should be significantly more rare. Similarly, these can only be created (barring any abilities from the arcane engineer subclass) in urban environments or places with large supplies of magic material for purchase as many of the construction materials are not found in the correct purities in the wild.

Arcane Engineers can also craft their own components given enough time. Using approximately one hour of down time they can create components at the level of:

Component	Crafting Cost
Capacitor	1GP $\times\mathcal{L}$
Battery	5GP $\times\mathcal{L}$
Resistor	6GP $\times\mathcal{L}$
Inductor	20GP $\times\mathcal{L}$

Table 3.4: Guide to cost of crafting components in down time where costs cover the necessary materials. $\mathcal{L}$ here stands for the level of item being crafted or purchased.

This table also acts as a guide for the cost of purchasing these components. The maximum level that can be crafted by an arcane engineer is equal to their maximum spell slot level.

As discussed previously in **Casters**, Arcane Engineers can also craft their own casters.

Spell Casting, Traps, and Learning

I debated this mechanic for a long while, but think I have settled on what makes the most sense to me. Spells cast through an arcane circuit behave very similar to regular spells (with regards to casting and what the player must roll). When a spell which would normally require a spell attack is made through an arcane circuit you designed then you will simply make it as a spell attack with your modifiers. This means, since the arcane engineer is a wizard subclass, you would be using your intelligence ability to calculate trajectories of your attack. Similarly spells which require choices of target creatures/people or locations for casting will work identically to as if you cast them normally (except for the fact they are in a circuit and the timings might be a bit different). If your circuit requires more manual aiming and is being used by another creature or person then they may make a ranged attack using the circuit as well as making the necessary selections.

Concentration checks, as discussed in **Inductors**, will be made by the inductor and the circuit rather than by you, where the modifier is determined by the inductor level.

Where things get a little more interesting is the presetting of arcane traps. This can be done in a few ways but I think the easiest is that the target must be predefined. For a spell which makes an attack, you can say whether it will attack the nearest creature (for example), or perhaps the biggest (it is up to your GM if you can add in flavour for devices such as "creature mass estimators" to your circuits if you want some extra fun). For spells which target a

Rarity	I (10GP)	II (20GP)	III (40GP)	IV (80GP)	V (200GP)	VI(400GP)	VII (800GP)	VIII (2k GP)	IX (4k GP)
Common (10GP)	(0,3,3,3,0)	(0,3,3,3,0)	(0,2,2,2,0)	(0,1,1,1,0)	(0,1,1,1,0)				
Uncommon (50GP)	(0,4,4,4,1)	(0,4,4,4,1)	(0,3,3,3,0)	(0,2,2,2,0)	(0,2,2,2,0)	(0,1,1,1,0)			
Rare (500GP)	(3,4,5,5,1)	(3,4,5,5,1)	(0,4,4,4,1)	(0,3,3,3,0)	(0,3,3,3,0)	(0,2,2,2,0)	(0,1,1,1,0)		
Very Rare (1k GP)			(3,4,5,5,1)	(0,4,4,4,1)	(0,4,4,4,1)	(0,3,3,3,0)	(0,2,2,2,0)	(0,1,1,1,0)	
Legendary (10k GP)				(3,4,5,5,1)	(3,4,5,5,1)	(1,4,4,4,1)	(1,3,3,3,1)	(1,2,2,2,1)	(1,1,1,1,1)

Table 3.3: A table showing example kits of arcane engineering components where the number in the brackets tell us the number of (Capacitors, Batteries, Resistors, Casters, Inductors) in each kit respectively. The column tells us the level of kit (and hence of components) The price of each kit is given by the sum of prices in the level and rarity labels (e.g.Legendary Level 9 kits will cost 14,000 GP).

specific creature (such as "charm" for example), you may choose to have targets such as "The first person to touch the object." For Area of Effect spells you must preset the location at which the spell will be cast (within range of course).

These are all fairly reasonable assumptions to be made and allow the system to work with the myriad of different spells possible. Once the trap is set I believe you would have to disarm the trap if there are relevant materials (i.e., pressure plates), maybe if your GM is nice they will give you advantage since it's your own trap.

If a spell requires a target it can "see" then the casting component must be able to draw a direct line of sight to the target.

Concentration

Spells which require concentration require an inductor in the circuit of equal or greater level to the spell being concentrated on. When the circuit is damaged it will make a constitution saving throw with a modifier equal to the inductor's level.

Counter Casting

Nice and simple: effects which dispel magic will result in the circuit not being able to cast, it will lose all spell slot charges stored in the battery, if you are a nice GM you may allow for components which grant some resistance to this effect (i.e., the circuit cannot cast but it will not lose any spell slots unless activated at which point it will lose the cast spell slot). Counters to spell casting specifically also work provided they satisfy the rules as if the circuit had cast like a creature, any associated checks or saves will be made by the arcane engineer as a stand in for their technical ability to craft resilient circuitry. Since the casting components are neither verbal nor somatic they are resilient to counters which typically silence spell casters.

Arcane Engineer Spells and Actions

These are few since the arcane engineer is a subclass of wizard and thus uses the wizard spell list. That said there have been some specialised spells that any wizard can learn but are of particular use to Arcane Engineers.

Repair Circuitry

1st level Transmutation

Casting time: 1 action
Range: Touch
Target: An arcane circuit which you touch
Components: V, S, M (spare arcane wire)
Duration: Instantaneous
Classes: Wizard

An arcane circuit you touch repairs itself with your touch gaining a number of hit points equal to 1d4 + your spellcasting ability modifier. This ability has no effect on creatures which are not constructs.

At Higher Levels: When you cast this spell using a spell slot of 2nd level or higher the healing increases by 1d4 for each slot level above 1st.

Stabilise

3rd level Transmutation

Casting time: 1 action
Range: Touch
Target: An arcane circuit which you touch
Components: V
Duration: Instantaneous
Classes: Wizard

You touch an arcane circuit built by a willing creature and immediately shield it within a protective sphere. While in this sphere the circuit cannot cast spells and has an additional +10 to its AC and advantage on all saving throws. If the circuit drops below 0HP while within the sphere it will return to 0HP at an initiative of 20.

Battery Dump

You may use an action to dump all remaining spell slots from your arcane battery you can touch into a 15 foot cone originating from your circuit. Creatures within the cone must make a Dexterity saving throw. A creature takes 1d6 damage for every level of each spell slot on a failed save and half as much on a successful one.

Circuit Rules Cheat Sheet

This is a simple rule sheet to cover all the rules required of circuit building so that both the player and GM can check that circuits are valid by the rules we have ascribed. These are the most simplified rules from the theory developed. There is more nuance available in the sections above, but these should allow for quick building and calculations.

1. General

1. All Component Levels must be less than or equal to the maximum spell slot level of the circuit's creator.
2. All circuits must contain a battery (or capacitor) which is connected to a caster. If that battery is above 0th level the circuit must have a closed loop back to the battery.
3. Spell slots of different level cannot pass through the same wire but can exist in the same circuit.
4. Circuits cannot cast ritual spells.
5. Only Arcane Engineers may charge batteries with their spell slots. Charging a battery takes one entire turn.

2. Spell Slot Storage

1. Spell Slot Batteries lose their charge after a long rest unless they are special components that negate this rule.
2. Spell Slot Batteries may only hold spell slots of level equal to theirs. Functionally the amount is beyond the limit of any caster but for edge-cases, we say a battery can hold 10 spell slots.
3. Spell Slot Capacitors may only hold one spell slot of level equal to theirs.
4. Different spell slot levels cannot be present in the same wire at the same time.

3. Resistors

1. The resistance along a given path[3] 'R' must satisfy $R \leq \frac{9}{\mathcal{L}}$ with '$\mathcal{L}$' equal to the level of spell slot passing through the resistors.
2. The delay of any particular path is calculated by multiplying the individual resistance along said path. If the battery's spell slot energy is split along multiple paths then the time will be multiplied by the number of paths the energy is split between[4].
   - **In combat**: The spell will cast at an initiative after the circuit is activated equal to the total resistance before the caster component.
   - **Out of combat**: The spell will cast at a number of seconds after activation equal to the total resistance before the caster component.

4. Inductors

1. Inductors must be equal to or greater than the spell level passing through them.
2. When a concentration saving throw is required, it is done with the usual rules with the constitution modifier of the circuit being equal to the inductor's level.
3. Two inductors of inductance L_1 and L_2 may transform from spell slots $\mathcal{L}_1 \rightarrow \mathcal{L}_2$ according to $\mathcal{L}_2 = \frac{L_2}{L_1}\mathcal{L}_1$.
4. Inductor based transformers require:

$$L_2 \leq L_1 \text{ s.t. } \mathcal{L}_2 \leq \mathcal{L}_1$$

5. Casters

1. Casters may cast any preexisting wizard spell in 5e
2. If the circuit is not equipped to a creature, the target(s) of a spell must be preset in general terms[5].
3. Spells will cast immediately when a full spell slot's worth of energy is in the caster component and not sooner or after.

Building Rules Checklist

Reiterating the rules relevant to circuit building: a circuit is stable if it satisfies the following:

- ☐ All Component Levels must be less than or equal to the maximum spell slot level of the circuit's creator.
- ☐ All possible paths begin and end with the same battery (a closed loop) with the exception of 0th level batteries.
- ☐ Different spell slot levels cannot be present in the same wire at the same time.
- ☐ The resistance along a given path[3] 'R'must satisfy $R \leq \frac{9}{\mathcal{L}}$ with '$\mathcal{L}$' equal to the level of spell slot passing through the resistors.
- ☐ Inductor level is greater than or equal to the spell level it will be casting.
- ☐ Transformers can only downgrade spell slots.

If the circuit fails to meet these requirements, then when the circuit is activated, you must roll on the Chaotic Circuit Failure Table (Next Page).

[3] Calculated by multiplying the individual resistances
[4] So if my level 1 battery is powering two casters it will take twice as long for both to cast
[5] e.g. "The nearest three creatures"

Chaotic Circuit Failure Table

This is a simple table that you must roll on if you break the rules of circuit construction or your circuit suffers a catastrophic failure. **After every effect, the circuit becomes inoperable unless otherwise stated.**

Chaotic Circuit Failure Table

d100	Effect	d100	Effect
01-02	Roll on this table at the start of each of your turns for the next minute, ignoring this result on subsequent rolls.	51-52	Roll a d8, that number of components in your circuit fail starting from the first component after the highest level battery and moving along the circuit.
03-04	The wire of the circuit begins to heat, resulting in 1d4 fire damage to the circuit and anything touching it.	53-54	An adhesive substance appears on your circuit, sticking it to whatever creature or object it is closest to for the next hour. It cannot be removed by any means until the hour is up.
05-06	For the next minute, you can change the spell cast through the spell caster at will to a spell of equal or lower level; after this minute, the caster will break and be unable to be used until replaced or repaired.	55-56	The wires in your circuit burn out, and any creature touching the wires takes 1d8 fire damage, and the circuit is unusable until new wires are installed.
07-08	A light-blue magic flare illuminates a region up to 30 feet around the circuit in light, clearly visible to any creature with line of sight within 500 feet.	57-58	The circuit fixes itself such that it no longer violates the rules at no cost to you.
09-10	Magic Missile is cast from each spell battery at the batteries level at a target of your choosing.	59-60	For the next minute, the circuit will change colours, cycling through the rainbow and back.
11-12	The range of spells cast through this circuit increases by 10 feet for a minute.	61-62	The circuit will release a brilliant bright light, blinding every creature within 30 feet of it if they fail a Constitution saving throw with your Spell Save DC.
13-14	The wires of the circuit glow, illuminating everywhere in line of sight with the circuit.	63-64	The circuit creates an arcane fog centered on itself that is the equivalent to casting Fog Cloud.
15-16	The Circuit casts Thunderclap centered on itself.	65-66	For the next minute, the circuit has effectively no weight.
17-18	The wires of the circuit begin to grow in length, dangling from their attached components. Any creature which was holding the circuit must make a Dexterity saving throw against the circuits DC. If they fail, they will become restrained. They may make a new Dexterity saving throw at the beginning of their subsequent turns until they succeed.	67-68	For the next minute, Silence is cast centered on the circuit and moves with the circuit.
19-20	The resistance of all resistors in the circuit become one, but the circuit does not break until after the casting.	69-70	The circuit will do nothing until the start of your next turn, at which point, it will cast as expected.
21-22	For the next minute, the weight of the circuit doubles, causing the wearer (if any) to have disadvantage on all Strength and Dexterity saving throws.	71-72	For the next minute, the circuit grants you some of its arcane power, giving you advantage on all Intelligence and Charisma saving throws.
23-24	The Circuit and the material it is attached to become invisible for the next 10 minutes.	73-74	For the next minute, the circuit releases random sparks, and if a creature enters or starts their turn within a 10 foot radius of the circuit, they must roll a Constitution saving throw with DC equal to your own spell save DC, taking 3d4 lightning damage on a failed save and half as much on a success.
25-26	For the next minute, the circuit becomes a creature that is passive and casts the same as before...just now, it looks and feels alive, with casters appearing like eyes. After that minute, the circuit dies and is not repairable. It keeps the AC and HP of the circuit it came from.	75-76	You may choose to either roll on this table again or take 1d4 fire damage.
27-28	For the next minute, any initiative delays to casting are halved, and activating the circuit now takes a bonus action.	77-78	For the next minute, any initiative delays to casting are doubled, and activating the circuit now requires an Action and movement.
29-30	The circuit teleports 60 feet to an unoccupied location in a direction determined by the result of a d4 roll (1 = forwards, 2 = right, 3 = behind, 4 = left). Otherwise, it is unchanged.	79-80	When you cast the next spell, the circuit will cast as many spells as there are spell slots remaining in its battery such that it targets the maximum number of different creatures, beginning with the one closest to it. If the spell has an Area of Effect they can be placed where the activator of the circuit chooses to target the largest number of targets possible with overlaps where possible.
31-32	The circuit is transported to another plane until the end of your next turn, after which time it returns to the space it previously occupied or the nearest unoccupied space if that space is occupied.	81-82	The circuit vanishes, and all components are lost.
33-34	The next damaging spell cast through this circuit deals maximum damage.	83-84	The circuit assumes the shape of a sphere, and if it was wrapped around any part of a creature (e.g., finger, arm, or head), they will take 2d8 bludgeoning damage.
35-36	The circuit begins to rust and wires will require replacing; until then, the circuit is inoperable.	85-86	The caster nearest the circuit restores one spell slot of equal level to the lowest level spell slot battery in the circuit.
37-38	For the next minute, the circuit can fly and behaves as a creature controlled by the GM with a flying speed of 40 feet; it is frightened of you. If it is attached to you, then you must make a Strength Saving throw to resist its desired movement.	87-88	The Circuit turns to water permanently, losing all components.
39-40	The circuit, through highly improbable magic effects, grants you another spell slot of equal level to its lowest battery level.	89-90	The circuit becomes confused and tries to pass lightning through its wires. Any creature touching any wire in the circuit must make a constitution save taking 3d8 lightning damage on a failed save and half as much on a success.
41-42	The Circuit transforms into a plant-like creature that behaves as the circuit normally does (i.e., it still functions) until the next long rest is taken at which point it decays and is not repairable.	91-92	The base object of the circuit is transformed into a mimic.
43-44	For the next minute, the spell cast by this circuit does not consume spell slot charges from the battery.	93-94	The circuit turns into a single gold coin, destroying all components in the process of its transformation.
45-46	For the next minute, the caster will cast Magic Missile at the level of battery provided. If the battery is level 0, then only one dart is cast.	95-96	The circuit begins to emit a high pitched buzzing that only you can hear for this turn, and next, you will take 1d4 psychic damage.
47-48	For the next minute, the circuit can speak and may choose not to cast its spells. You may attempt to convince it with persuasion or intimidation skill checks with a DC equal to your spell save DC.	97-98	You so fundamentally break the fabric of magic around you that no spells may be cast within 60 feet of the circuit for the next minute.
49-50	All components become gold, each worth about 50GP. After 24 hours, the components will return to their normal material, and if the circuit has not been altered, it will return to functionality again.	99-00	The circuit immediately casts all the intended spell(s) of the circuit on itself simultaneously.

Chapter 4: The Arcane Engineer Subclass

As an Arcane Engineer, you seek the mastery of the practical application of magic theory. More traditional wizards might look upon your work as strange and dangerous when compared to the more traditional specialisations of orb ponderers, pointed hats, and heavy books. Non-wizards might see your rules as an unnecessary restriction on their more chaotic constructs. In reality, you know that it is through a careful understanding of these rules you can bring the consistency and danger of a well-trained wizard to the creativity and practicality of real-world systems. Upon taking this subclass, you learn the action **Battery Dump** (see above).

Component Savant

You've begun to familiarise yourself with the components of your circuits, their theory, and their materials. Using this knowledge from second level and higher, you can create circuits provided you have the correct components. Crafting and purchasing components is limited to areas with sufficient materials such as urban environments or locations with sufficient materials in the correct quality for components.

Additionally, you may also repair a circuit which has had its HP drop below 0 provided it has not dropped below the negative of its maximum HP.

Component Specialist

Starting at sixth level, you may increase the level of components not embedded into circuits by one for a quarter of the standard cost (given in chapter 3) of constructing a component at this higher level. You may upgrade a component as many times as you like up to a level equal to or less than your maximum spell slot level.

Scavenger

Your deep understanding of the components that build magic circuits allows you to find suitable replacements from your surroundings without the need to purchase or craft new components. Starting from tenth level, you may use a day of down time to find 10GP worth of component equivalents at no cost to yourself. These equivalents can be found in all environments and will act exactly as a normal component would.

Theorist

At levels 14 and higher, your understanding of magic circuitry is so deep, you are no longer bound by the material costs of components; instead, you can create a theoretical magic circuit on a chosen object that acts exactly the same as a physical circuit would. To see the circuit a creature must make an investigation check with DC equal to your spell save DC. The circuit must follow the standard rules of circuit construction, and you may only have one of these circuits at any given time. Only you may use this circuit and it does not interfere with other circuits. Once per long rest, you may reconfigure the circuit and its components however you like.

Art Credit: George Eracleous

Chapter 5: Arcane Engineering Examples

Background

The following are example circuits taken from one of the university's top professors Elyn Sparkfire. Her scrawlings have been found on various blackboards, scraps of paper, walls, books, desks and occasionally students around the University of Theoretical Magic. Despite her...eccentricities...she has pioneered the field, and it would not be right to ignore her contributions. In each section, I will describe the circuit, its workings, and the circumstances in which we found them. Please use at your own risk.

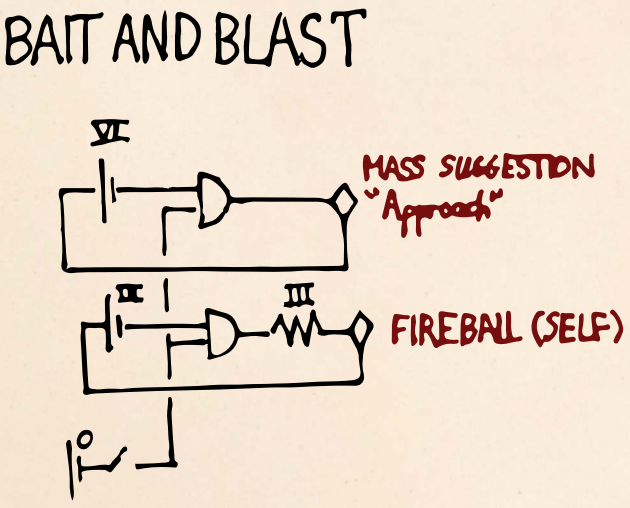
Bait and Blast

The Bait and blast was proudly displayed (without my prior knowledge) at the first ever convention for limiting magic's use in warfare. Elyn told me she planned on demonstrating the risks of arcane engineering's contributions to warfare, and to her credit, she certainly made her point.

Built into a throwable object, the Bait and Blast is comprise of two connected circuits. Both are activated by a simple switch, though I'm told a sensor or other cantrip-based detector would work. When the button is pressed, the cantrip energy is passed to both circuits and through the AND gates, allowing their spells to pass. The first (top) circuit uses a 6th level battery to cast Mass Suggestion with the predefined suggestion "Approach." Unsuspecting victims will then walk towards the device. The second (bottom) circuit will then cast fireball on itself, destroying the device and anyone nearby. The third level resistor slows the casting just enough for the approach command to take effect. After we had quite securely drained the batteries at the convention, Elyn decried the lack of

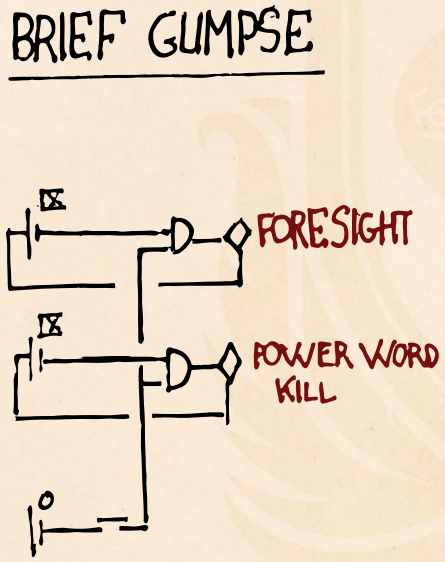
1. A more effective low level area of effect spell for which to attack the victims.
2. A lower level, less long lasting, version of Mass Suggestion which might allow for construction that less valuable resources.

Needless to say, I checked Elyn's work before any future displays.



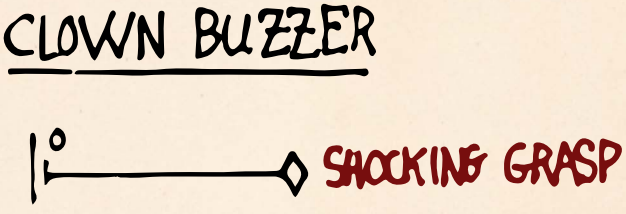
Brief Glimpse

I found a box on my desk one day containing this circuit. The "Brief Glimpse" first casts Foresight on the person to first touch the box. It then, almost immediately after, casts Power Word Kill. Naturally, being the middle of a work day, I was in good health and not affected by the spell. I was, however, quite affected by the howling laughter of Elyn as she fell out from her hiding place in my office, spluttering out the words, "You should have seen your face!" between her cackles. I did not find it as funny. Very dangerous circuitry.



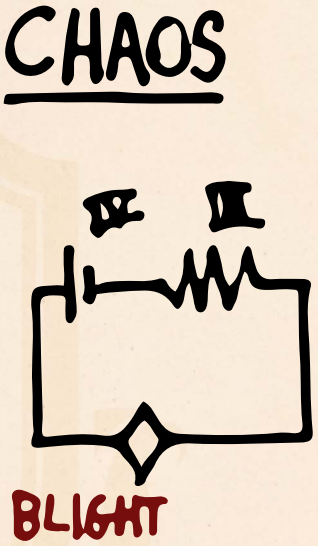
Clown Buzzer

A favourite of Elyn's at formal occasions, a simple cantrip battery takes energy from the surrounding environment, and channels it into a shocking grasp. Very funny to the right crowd.



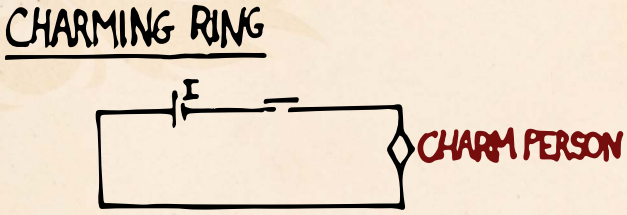
Chaos

When I first saw this diagram on the blackboard of Elyn's lab, I assumed it was a simple mistake. It was only when I heard the thud of six magic missiles (a 9-10 on the Chaotic Circuit Failure Table) and her triumphant shouts, I realised what she had done. The circuit is **DESIGNED TO FAIL** to induce one of the chaotic effects arcane engineering can lead to. The fourth level spell slot backs up at the third level resistor, resulting in a build up of magical energy. If it somehow doesn't fail, it still casts Blight, a strangely dangerous choice. I believe the goal of this research was to find a way of inducing certain chaotic effects more often than others, but to date, this research has not yielded expected results.



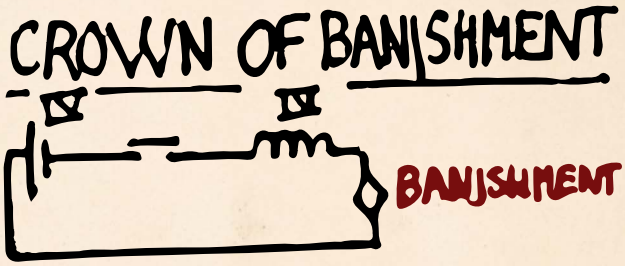
Charming Ring

A fantastic ring that I must admit to having borrowed for one or two important meetings. A simple contraption, small enough to fit on a ring and appear stylised, it will cast charm person on the person who activated it (likely during a handshake or other greeting).



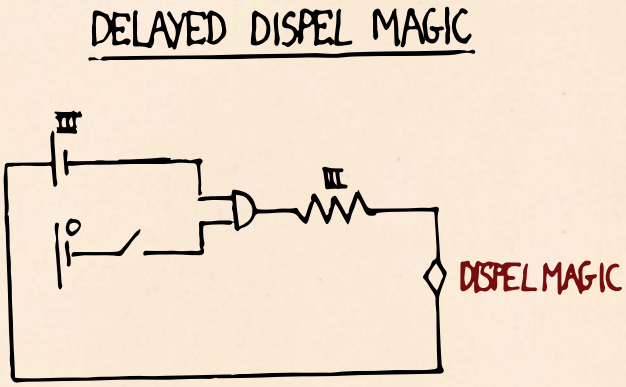
Crown of Banishment

When she was reading too many fantasy novels, Elyn created this as a trap for any descendant of exiled kings. "You know, the type that roam around with birthmarks and swords, joining humble jobs like the city guards until one day they slay a dragon and overthrow whoever ran the city before," she told me. The wearer sees this crown, but unless they are observant enough they will not notice the circuitry hidden on the inside. When they put the crown on, it will cast banishment, keeping concentration using the inductor. I've been told this should give them ample time to reconsider their lordliness.



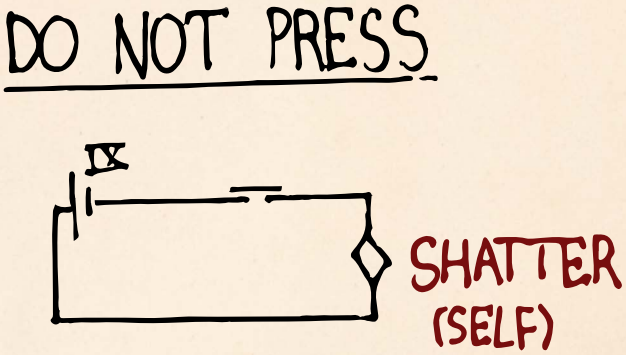
Delayed Dispel Magic

This is actually one of Elyn's latest inventions after a few grumblings from some of the other academics. This is an emergency magic dispelling circuit that can be activated manually, giving a short delay and then casting dispel magic. The delay is so that the item may be thrown or allow someone relying on other magic to get out of the dispelling field's way.



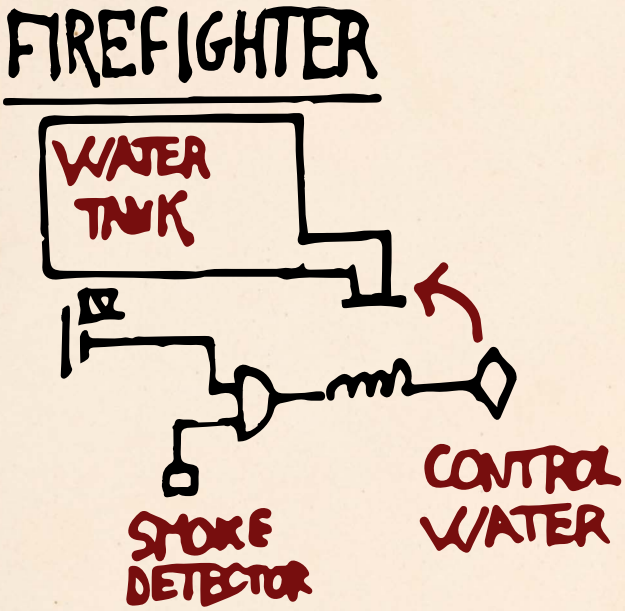
DO NOT PRESS

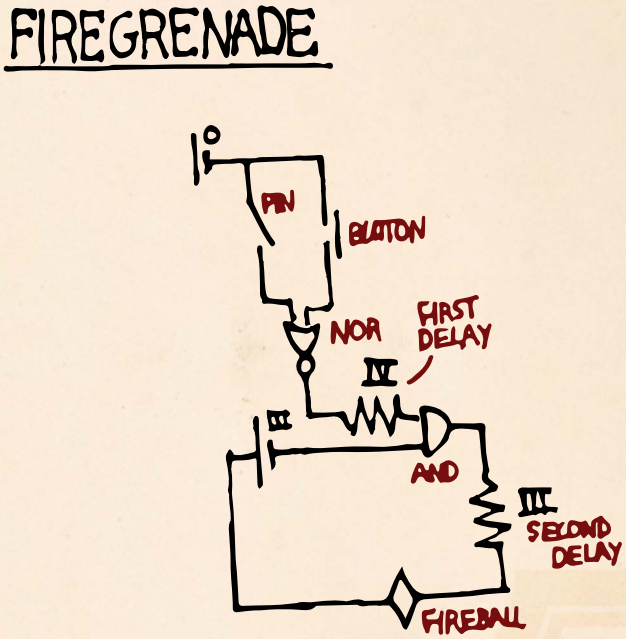
Elyn has recently been trying to work on her cross-disciplinary research, and this was her attempt at something called "psychic-ology." She placed this circuit in the centre of the student halls along side a large magic sign saying, "DO NOT PRESS." She aimed to show how trustworthy both our signs and students are. When the button is pressed, it casts shatter at 9th level. She is *very* lucky it was Wizard Wenda who pressed this first and not one of our more fragile students. Wenda was simply enraged and cast "Hit with Axe" a few times. Which reminds me to follow up on exactly what her qualifications were.



Firefighter

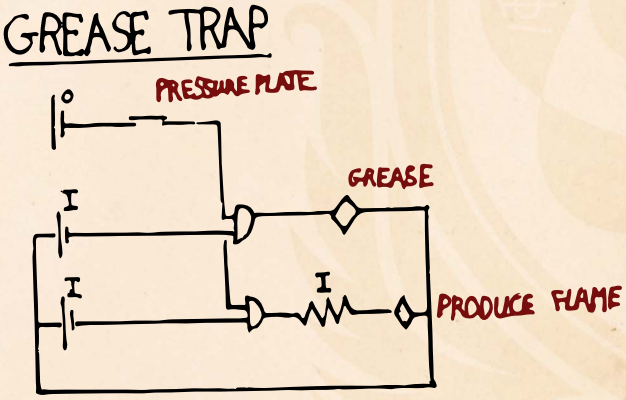
One of Elyn's most useful inventions. A smoke detector allows cantrip level energy to pass to the AND gate if it detects any smoke; this then allows a fourth level battery to cast control water on a nearby reserve, which is directed to the source of the fire. I have personally seen to it that these have been installed in our most flammable labs and library sections.





Grease Trap

Elyn had this brilliant idea while discussing food preparation within the university. The circuit simply activates when a pressure plate is stepped on, first casting grease, then almost immediately after casting produce flame with a one-second delay. This was not intended for use in kitchens.



Fire Grenade

In protest of the number of her resources used to put the "Firefighter" circuit throughout the university, Elyn created the "Fire Grenade." It begins with the pin switch closed, which stops any current passing from the NOR gate. You then press the button (similarly preventing the NOR gate from giving an output) and then release the pin. Now, when you release the button, there will be a four-second delay. After this, the AND gate will activate and the third level fireball will undergo another three-second delay before casting. This allows for the object the circuit is built into to be thrown. Say what you must, but there is no doubting the effectiveness of Elyn's work.

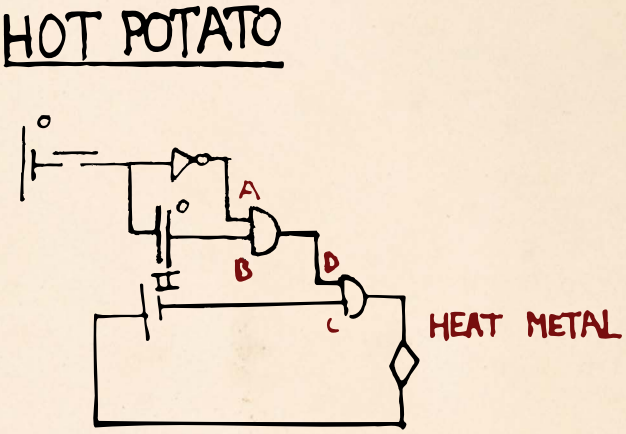
Hand-held Fan

The first time I became aware of this invention was during a warm summers day when Elyn and I were strolling through the campus. Being far too warm, she produced a hand held fan; unfortunately, I was not paying enough attention and only noticed the circuit as we were both thrown 15 feet across the green. She has assured me she is looking into a way of reducing the impact of the gust while still keeping the circuit handheld. That said, the alchemy department have put this to great use.

Hot Potato

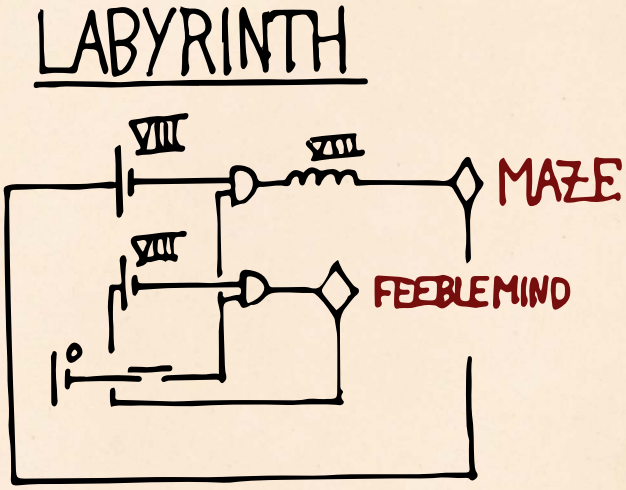
While explaining the power of non-magical suggestion during a lecture, a student insisted she was wrong. In response, Elyn reached into her drawer and withdrew this brass ball, shouting "catch!" at the student, and then subsequently filling out a **lot** of paperwork and a handful of written apologies to everyone involved.

Initially, the cantrip capacitor is uncharged and the button open, which stops the AND gate (A and B) from activating. After pressing, the capacitor charges, but the NOT gate inverts the signal again keeping the AND gate off. After the button is released, the cantrip signal from the capacitor and the NOT gate allows the signal to flow, casting heat metal on the ball it is built into. In layman's terms, if you press the button then release, it will get dangerously hot. Elyn would like to reiterate how sorry she is to the students affected and how much she has grown as a person during her resulting temporary suspension from teaching.



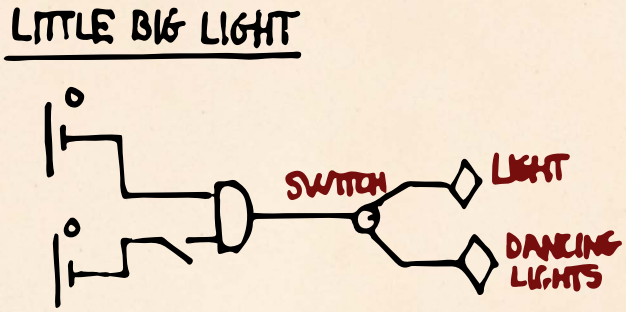
Labyrinth

This was one of Elyn's earlier "pranks" for another member of staff with which she had had enough. The "Labyrinth" first casts Feeblemind on the target foolish enough to press the button before Maze is cast on them. Trapping them until the spell ends.



Little Big Light

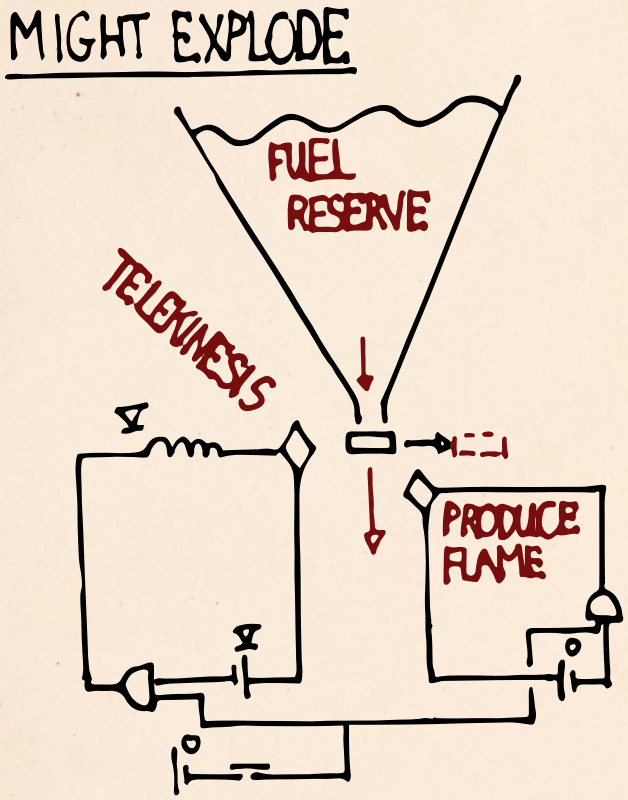
A charming device Elyn uses at her desk when marking. With a simple switch, the object will either cast light or dancing lights depending on how much light she needs for her work. I recieved a similar circuit for my anniversary of ascension to Archmage and am thrilled.



Might Explode

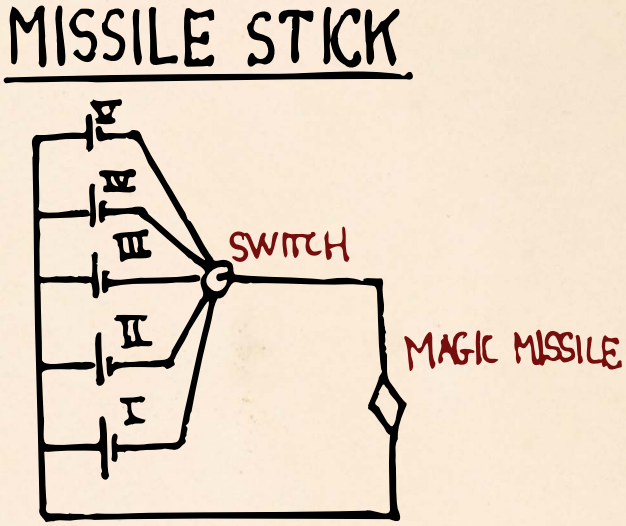
Elyn's most terrifying invention to date, simply because even she refuses to test it. A funnel

containing some flammable liquid (e.g., lamp oil) is held in a high place like a ceiling. A small glass plate prevents fuel from leaving. With the press of a button, the right hand circuit creates a flame and the second casts telekinesis, which pushes the glass plate aside, allowing the fuel to fall. Her concern is that the fuel may catch inside the reserve as it is not falling fast enough, so instead of having the desired effect of dropping liquid fire onto her victim, it may cause an explosion, which is "no use at all."[1]



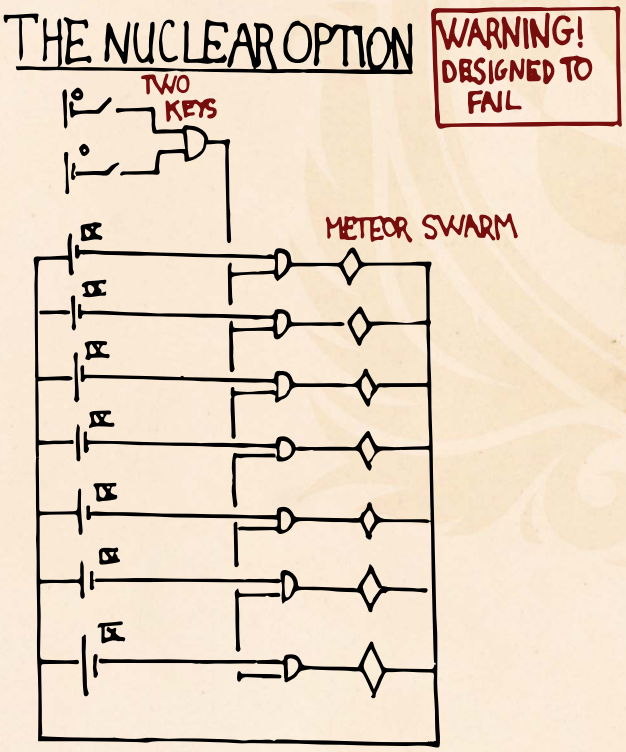
Missile Stick

A simple but cunning invention styled to look like a standard wizard's wand but significantly less versatile. By a radial switch, you can select the level of magic missile you wish to cast. A favourite of our one and only Reliable Ron, who insists on only casting Magic Missile. The power of this device seems to mostly be in the reliability of its application within other circuits and as a demonstration of the use of switches.



Nuclear Option

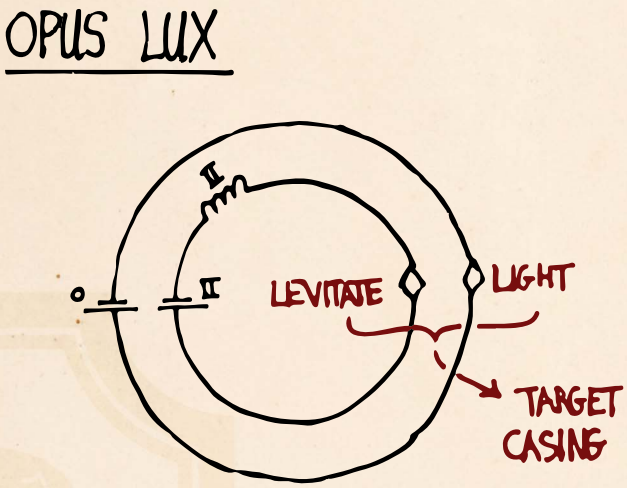
Elyn proposed this to me during a staff meeting once, and I hope she hasn't begun construction and never will. The circuit is comprised of as many Ninth level batteries as you can find, each casting meteorswarm at a predetermined location. In order to switch on, the master AND gate must be activated by the turning of two keys. She suggested I have one and she have the other, which is a much better idea than her having both (or the only) keys.



[1]Were you to use this in game, I'd say that it has to "succeed" a +0 saving throw against its creators spell save DC (i.e., the circuit wants to explode, but only if it's clever enough to circumvent design).

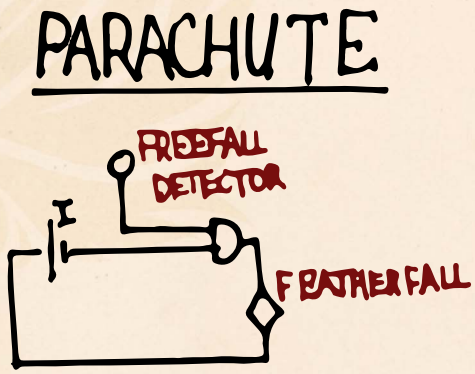
Opus Lux

A fancy old language for "Work Light", this orb sits in the center of Elyn's work bench. When activated, it will cast Light and Levitate on its own casing, floating above her station and providing a bright light from which to work.



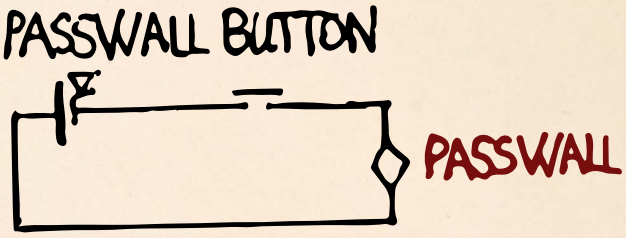
Parachute

A small detector inside this device detects whether the object is or is not in free-fall and, if it is, casts feather fall on the nearest creature. I only discovered this when Elyn leapt from one of the tallest towers of the university and landed with some grace about 300 feet below her. While it doesn't have any damaging components, it certainly inflicted some sort of psychic damage on me.



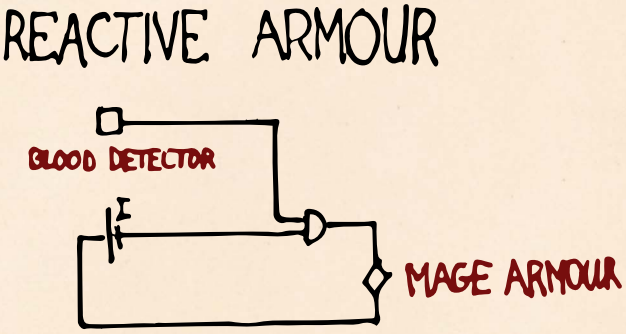
Passwall Button

For years, Elyn used buttons like these she had hidden around the university to get around without being pestered by students, staff, or anyone else. While I don't condone such behaviour, it has been exceptionally useful to know the location of a few of these. By my count, there are currently thirty-six hidden within the campus.



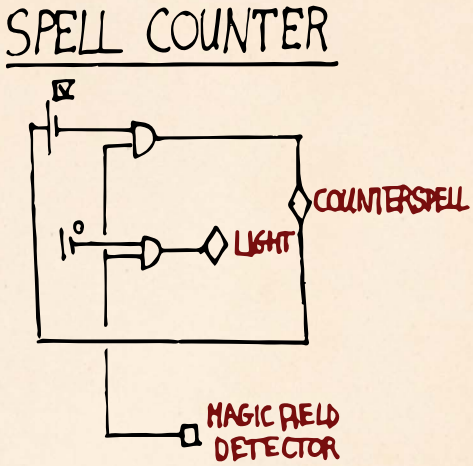
Reactive Armour

In her aforementioned fixation on fiction novels, Elyn decried her inability to effectively use plate armour due to her "academic levels of strength." When I pointed out that we have Mage Armour, she frustratedly said that it required you to cast it when the time was right rather than when you needed it...at which point, she ran off to her workshop. This is a simple ring or brooch over an area of interest where a sensor detects blood and casts Mage Armour. While I'm sure some battle mages might find this helpful given Elyn's broader lifestyle, this has mostly resulted in her gaining armour after giving herself a paper cut.[2]



Spell Counter

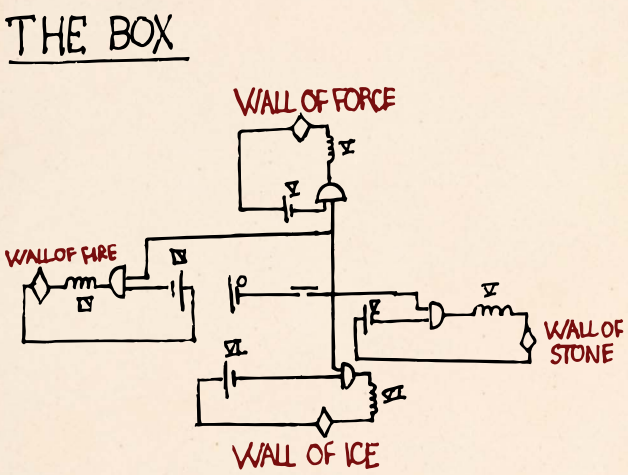
A now commonplace circuit amongst our graduates, the spell counter detects perturbations in magic fields and casts counterspell. This doesn't always work, of course, as the circuit may not be able to see the caster. Regardless, it will also give a light indicator to the user to say that a spell has been (or attempted to be) countered. This is especially useful if you intend on adventuring in high risk regions.



[2] In game I would take this as undergoing slashing, bludgeoning, piercing, or force damage.

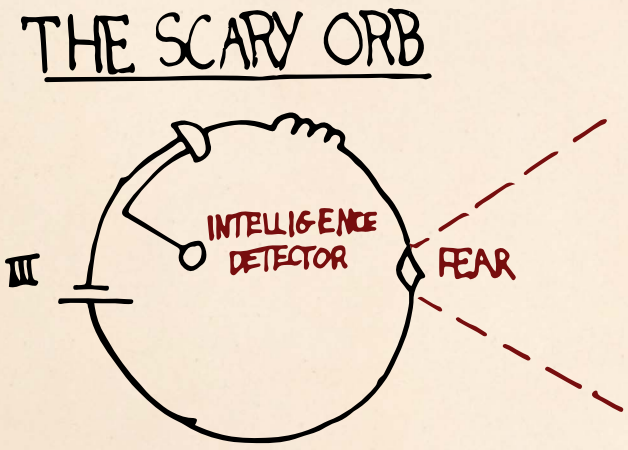
The Box

Regretfully, students will sometimes disagree with their lecturer's grades and challenge them. In this particular case, a student challenged Elyn who had failed them for "Not considering all eventualities." She decided to give the student a final chance, and they could make any contraption they wanted to and try to escape whatever trap she made, and if they did, she would pass them. Assuming she would simply make some form of counterspell device, they opted to avoid any teleportation magic and instead decided to make a counter-counter spell circuit to win this "duel." Clearly, they had not been paying attention to who was lecturing them as they failed to counterspell one of the four walls that erupted around them. This device is a little too flashy and irregular for my tastes, but I do enjoy a tale of hubris. Were I to remake this, I would simply choose one type of wall.



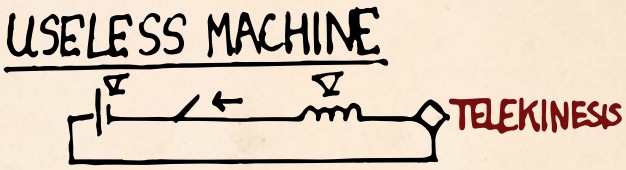
The Scary Orb

This was actually Elyn's first ever contraption which she made as an undergraduate. Mostly used to keep away the folk she didn't want to be near, 'The Scary Orb' simply detects intelligence[3] and casts in their general direction. She still carries this orb at the end of her staff to this day.



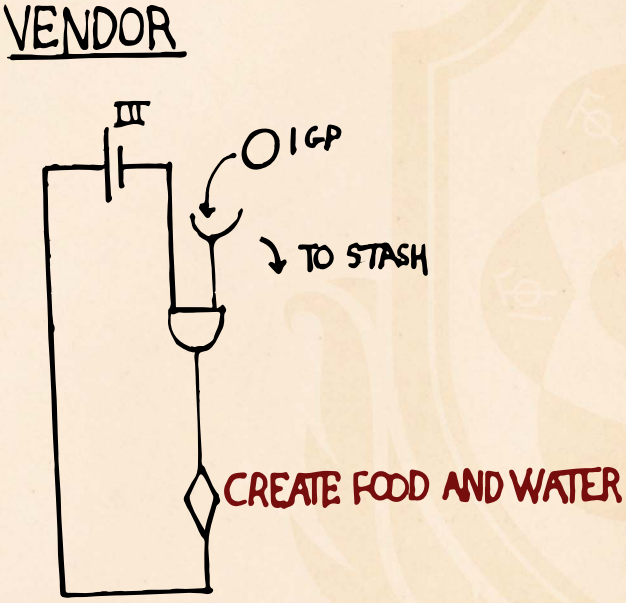
The Useless Machine

A fun side project she has every student make in their first advanced class. A simple machine which casts telekenisis to shut itself off. Fascinating, if useless.



Vendor

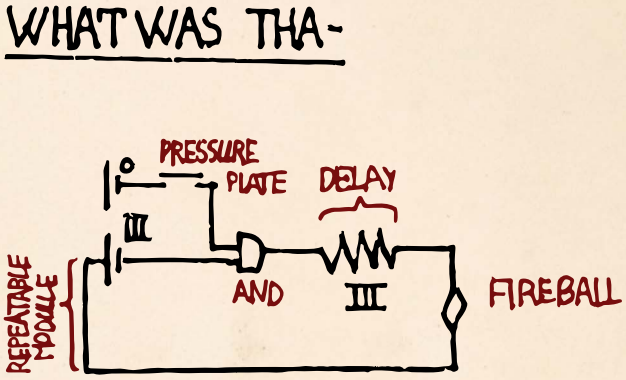
To help raise funds for certain faculty events, Elyn made this, an automated arcane vendor. which will dispense food and drink when provided with coins. This has proved a highly successful way of earning a passive income.



[3]For a game rule, I would say its a simple 1d20+0 check for the circuit to detect the target with a DC of 10 minus target's intelligence modifier (i.e., smarter people are easier to detect).

What Was Tha-

This circuit is used to help teach students the importance of comedic timing. When the pressure plate is pressed, there is a three-second delay followed by a fireball. Elyn says it is an important Arcane Engineering principle to be able to anticipate the words that your targets will say as a good punchline will ensure maximum effectiveness. I'm not sure I agree, but the results speak for themselves.



Chapter 6: Acknowledgements

In particular, I would like to thank Stenis for his work on the background graphics, foreground graphics (such as the Theory of Magic logo), and circuit diagrams in the final chapter. Graphic design is not my passion but I'm very fortunate to know people for whom it is. While the effect of the background graphics and the footer are subtle they add a huge amount to the overall feeling and impact of the work. You can see his other work at his twitter: '@___stenis___' or his Bluesky: '@stenis.bsky.social'.

I would also like to thank George Eracleous for his incredible cover art, component sketches, and concept art for the Arcane Engineer subclass. Be sure to check out his artstation (https://www.artstation.com/theredcow).

One of the great joys of this work is getting to talk to so many talented people and coordinate their talents into my mediocre ideas, which I always feel gives these things a veneer of professionalism I have not earned.

I'd also like to thank my editors. There were three that had the misfortune of working with me. My apologies to the editor who simply had to check for grammar and spelling. I seem to view grammar as a series of suggestions rather than rules that helps readers, and so they found 600 places where I needed to put commas. Secondly, I had an electrical engineer review my real-world introductions, mostly so I had someone else to share the blame with for my own idiocy. Finally, and certainly not least, I would like to thank Jesús Blanco Artero for his incredible work helping me balance the game-play applications of this work. I wish I could pretend I had thought of every eventuality and come up with good systems first try, but alas I am stupid. Jesús found a lot of areas for improvements in my rough foundations, and with our constant back and forth we were able to come up with a system I'm very happy with. Especially for systems like the custom casters, you are seeing a large amount of work from him.

Lastly, I'd also like to thank you and all the other readers for your continued support of my various works and patience with how long it takes to write. Hopefully, you will continue to enjoy the nonsense I write in the future. I'd appreciate if you left a review, but a lot of this book was a lot of hard work on your part, so I don't think I can ask you for much more than that.